DRAFT FINAL
DETAILED ANALYSIS
OF ALTERNATIVES REPORT
VERSION 2.0
SOILS DAA
VOLUME II of VII

JULY 1993
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THE CONDUCT OF THE FEASIBILITY STUDY (FS) UNDER CERCLA IS ACCOMPLISHED IN TWO STEPS. THE FIRST STEP, THE DEVELOPMENT AND SCREENING OF ALTERNATIVES (DSA), INVOLVES IDENTIFYING AND SCREENING A BROAD SELECTION OF ALTERNATIVES THAT ACHIEVE THE REMEDIAL ACTION OBJECTIVES (ROAS). THE SECOND STEP IS THE DAA. THE OBJECTIVES OF THE DAA INCLUDE THE FOLLOWING: (1) PROVIDE A MORE DETAILED DEFINITION OF EACH ALTERNATIVE RETAINED IN THE DSA, AS NECESSARY, WITH RESPECT TO THE VOLUMES OR AREAS OF CONTAMINATED MEDIA TO BE ADDRESSED, THE TECHNOLOGIES TO BE USED, AND ANY PERFORMANCE REQUIREMENTS ASSOCIATED WITH THOSE TECHNOLOGIES. (2) ASSESS EACH ALTERNATIVE AGAINST THE DAA EVALUATION CRITERIA IDENTIFIED IN THE NATIONAL CONTINGENCY PLAN AND DEFINED IN U.S. EPA GUIDANCE (EPA 1988). (3) PERFORM A COMPARATIVE ANALYSIS AMONG THE ALTERNATIVES TO EVALUATE THE RELATIVE PERFORMANCE OF EACH ALTERNATIVE WITH RESPESCT TO EACH EVALUATION CRITERION. (4) SELECT A PREFERRED ALTERNATIVE FOR EACH MEDIUM GROUP BASED ON THE COMPARATIVE ANALYSIS. THE DAA REPORT CONSISTS OF SEVEN VOLUMES. VOLUME I - EXECUTIVE

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VOLUME II of VII

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/l	micrograms per liter
3-D	three-dimensional
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos–containing material
AMC	Army Materiel Command
AOC	Area of Contamination
AOPs	advanced oxidation processes
AR	Army Regulations
ARARs	applicable or relevant and appropriate requirements
Army	U.S. Army
atm-m^3/mol	atmospheres per cubic meters per mole
ATP	Anaerobic Thermal Processor
ATSDR	Agency for Toxic Substances and Disease Registry
BCY	bank cubic yard
BDAT	best demonstrated available technology
BEST	Basic Extraction Sludge Treatment
BFI	Browning Ferris Industries
BOD	Biological Oxygen Demand
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTU	British thermal unit
CAMU	Corrective Action Management Unit
CAR	Contamination Assessment Report
CCA	chromated-copper-arsenate
CCR	Code of Colorado Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CLC2A	Chloroacetic Acid
cm/sec	centimeters per second
cm^2	centimeters squared
COC	contaminant of concern
CPE	chlorinated polyethylene
CPRP	Chemical Personnel Reliability Program
CRL	certified reporting limit
CSI	Conservation Services, Inc.
CSPE	chlorosulfonated polyethylene
CWA	Clean Water Act
CY	cubic yards
DA	Department of the Army
DAA	Detailed Analysis of Alternatives
DADS	Denver Arapahoe Disposal Service, Inc.
db(A)	decibels
DBCP	dibromochloropropane
DCPD	dicyclopentadiene
DDE	dichlorodiphenylethane
DDT	dichlorodiphenyltrichloroethane
DHHS	Department of Health and Human Services
DIMP	diisopropylmethyl phosphorate
DNAPL	dense nonaqueous phase liquid
DOD	Department of Defense

DOT	Department of Transportation
DRE	destruction removal efficiency
DRMO	Defense Reutilization and Marketing Office
DSA	Development and Screening of Alternatives
EA	Endangerment Assessment
Ecology	U.S. Ecology, Inc.
EDSVEP	Enhanced Deep Soil Vapor Extraction Process
ENSCO	Environmental Systems Company
Envirosafe	Envirosafe Services of Idaho, Inc.
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
ERC	Ecological Risk Characterization
ESSVEP	Enhanced Surface Soil Vapor Extraction Process
ETTS	Ecotechniek Thermal Treatment System
FC2A	fluoroacetic acid
FFA	Federal Facility Agreement
FML	flexible membrane liner
fpm	feet per minute
FRP	fiber - reinforced plastic
FS	feasibility study
ft/day	feet per day
ft	feet or foot
ft^3	cubic feet
GAA	granulated activated alumina
GAC	granular activated carbon
GB	isopropylmethylphosphonosfluoridate (nerve agent-sarin)
gpm	gallons per minute
H:V	horizontal to vertical
H_2O_2	hydrogen peroxide
HBr	hydrogen bromide
HCCPD	hexachlorocyclopentadiene
HCL	hydrochloric acid
HCPD	Hexachloro pentadiene
HDPE	high-density polyethylene
HE	high explosive
HEP	habitat evaluation protocol
HEPA	high efficiency particulate
HF	hydrofluoric acid
Hg	mercury
HHEA	Human Health Exposure Assessment
HHRC	Human Health Risk Characterization
HI	hazard index
ICP	inductively coupled plasma
ICS	Irondale Containment System
IDLH	Immediately Dangerous to Life and Health
IEA	Integrated Endangerment Assessment
IITRI	IIT Research Institute
IRA	interim response action
IT	International Technology
IWT	International Waste Technologies
K_{oc}	partition coefficient
kw	Kilowatt
kWh	Kilowatt hour

L	Lewisite
lbs	pounds
lbs/acre	pounds per acre
LCY	loose cubic yards
LCY/hr	loose cubic yards per hour
LDR	land disposal restriction
LF	Linear Foot
LNAPL	light nonaqueous phase liquid
LT^3	Low-Temperature Thermal Treatment
LTTA	Low-Temperature Thermal Aeration
mg/l	micrograms per liter
mg/cm^3	milligrams per cubic centimeter
mg/m^3	milligram per cubic meter
mg/kg	milligrams per kilogram
mg/l	microgram per liter
MKE	Morrison–Knudsen Engineering
ml/g	milliliters per gram
mm	millimeters
MMBTU	million British thermal units
mph	miles per hour
MTR	minimum technology requirement
NaOH	sodium hydroxide
NBCS	North Boundary Containment System
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NWBCS	Northwest Boundary Containment System
O&M	operations and maintenance
OAS	Organizations and State
°C	degrees Centigrade
OCP	organochlorine pesticides
OCPD	dicyclopentadiene
°F	degrees Fahrenheit
OPHGB	organophosphorus compounds, GB-agent related
OPHP	organophosphorus Compounds; pesticide related
OSCH	organosulfur compounds; herbicide related
OSCM	organosulfur Compounds; mustard agent related
OSHA	Occupational Health and Safety Administration
PAHs	polynuclear aromatic hydrocarbons
PBC	probabalistic biota criteria
PCB	polychlorinated biphenyls
pcf	pounds per cubic foot
PCP	pentachlorophenol
PEC	plume evaluation criteria
PKPP	potassium pyrophosphate
ppb	parts per billion
PPE	personal protective equipment
PPLV	preliminary pollutant limit value
ppm	parts per million
PRG	preliminary remediation goal
psi	pounds per square inch
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RAO	remedial action objectives

RCRA	Resource Conservation and Recovery Act
RF	radio frequency
RI	Remedial Investigation
RISR	Remedial Investigation Summary Report
RMA	Rocky Mountain Arsenal
ROD	Record of Decision
RPO	representative process option
SACWSA	South Adams County Water and Sanitation District
SAR	Study Area Report
SARA	Superfund Amendments and Reauthorization Act
SCC	Secondary Combustion Chamber
SEC	Site evaluation criteria
SF	square feet
Shell	Shell Oil Company
SHO	Semivolatile halogenated organics
SITE	Superfund Innovative Technology Evaluation
STC	Silicate Technology Corporation
SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
SY	square yards
T.DI.	Services HT-5
TBC	to be considered
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TEA	triethylamine
TEC	Target Effluent Concentrations
TIS	transportable incineration system
TMV	toxicity, mobility, and volume
TOC	total organic carbon
tpd	tons per day
TSCA	Toxic Substances Control Act
TSD	Treatment Storage and Disposal
TSMG	two-step geometric mean
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USPCI	U.S. Pollution Control, Inc.
UV	ultraviolet
UXO	unexploded ordnance
VAO	volatile aromatic organic compounds
VHC	volatile hydrocarbon compounds
VHO	volatile halogenated organics
VOC	volatile organic compound
VX	ethyl s-dimethyl aminoethyl methyl phosphonothiolate (nerve agent)
WES	Waterways Experimental Station

1.0 INTRODUCTION

As part of the on-post feasibility study (FS) at Rocky Mountain Arsenal (RMA) the Soils Detailed Analysis of Alternatives (DAA) was performed to provide the basis for identifying the preferred alternatives for the Record of Decision (ROD). The DAA is the final step of the overall remedial investigation/feasibility study (RIFS) being conducted at RMA. The FS is being conducted in accordance with the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA), the National Contingency Plan (NCP), the National Environmental Policy Act (NEPA), the RMA Federal Facility Agreement (FFA) (EPA et al. 1989/RIC 89068R01), and U.S. Environmental Protection Agency (EPA) guidance. The FS is designed to develop protective, cost-effective, and technically feasible remedial alternatives that address contamination identified in the RI.

The DAA report is divided into five parts: Executive Summary and Introduction, Technology Description Volume, and separate volumes for water, structures, and soils media. The Soils DAA report further defines the alternatives selected in the Soils Development and Screening of Alternatives (DSA), which is the first step of the FS process, by evaluating the alternatives based on the DAA evaluation criteria, as provided in the NCP (EPA 1990) and by providing a comparative analysis of the alternatives.

The Soils DAA focuses on remedial alternatives for the soils medium, which consists of unsaturated soils, bedrock, fill material, process water lines, chemical and sanitary sewer lines, lake sediments, and soil/debris mixtures in disposal trenches or landfills. The term "soils", used for convenience in this document, refers to any of these materials. The Soils DAA also considers interactions with other media of concern at RMA - water and structures - where it is clear that interactions occur between the media.

This report is divided into the following sections:

- Section 1—Describes the purpose of the DAA, overall background of RMA, remedial action objectives (RAOs) and soils evaluation criteria.

- Section 2—Describes the approach to dealing with interactions between the soils medium and the groundwater, structures, air, and biota media.

- Section 3—Describes the methodology employed in the Soils DAA as well as changes in approach since the DSA was conducted.

- Section 4—Provides a discussion of the modifications to the alternatives retained in the DSA and a detailed description of all alternatives used for the soils medium groups.

- Sections 5 through 19—Present the evaluation of alternatives for each medium group and for the respective subgroups.

- Section 20—Provides a summary of the preferred alternatives for the Human Health, Biota, Potential Agent Presence, and Potential Unexploded Ordnance (UXO) Exceedance Categories.

1.1 PURPOSE

The overall objective of the RI/FS process is to gather information sufficient to support an informed risk management decision regarding the most appropriate site remedies (EPA 1988a, b). The purpose of the DAA is to evaluate and compare remedial alternatives that achieve the RAOs and are protective of human health and the environment, and to select the preferred alternative. Accordingly the DAA accomplishes the following:

- Provides further definition of each alternative retained in the DSA, as necessary, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies

- Assesses each alternative against the DAA evaluation criteria identified in the NCP and defined in EPA guidance (EPA 1988)

- Performs a comparative analysis among the alternatives to evaluate the relative performance of each alternative with respect to each evaluation criterion

- Selects a preferred alternative for each medium group or subgroup based on the comparative analysis

The DAA accomplishes these objectives by following a prescribed sequence of steps, which are described in more detail in the following section of the Soils DAA. Due to the complexity of RMA sites and the unique combinations of contaminants, the standard EPA guidance steps are adapted to site-specific conditions. At RMA, for example, "medium groups" were used to identify and evaluate remedial alternatives for soil sites, groundwater plumes, and structures having similar historical usage and/or containing similar contaminants and contaminant distributions. Additional RMA-specific modifications to the DAA process are necessary to integrate the three contaminated media—soils, water, and structures. The proposed remedial alternative for soils may have a profound impact on proposed alternatives for both water and structures.

The alternative evaluation process in the DAA provides the Army with sufficient information to adequately compare the alternatives, select an appropriate remedy for RMA sites, and demonstrate the adequacy of the CERCLA remedy selection requirements in the ROD. The EPA evaluation criteria of state and community acceptance are formally addressed as part of the responsiveness summary in the ROD.

1.2 BACKGROUND

RMA was established in 1942 by the U.S. Army and was used as a manufacturing facility for the production and dismantling of chemical and incendiary munitions. Industrial and agricultural chemicals, primarily pesticides and herbicides, also were manufactured at RMA by several lessees, most notably Shell Oil Company (Shell).

The introduction to the DSA (EBASCO 1992b/RIC 92363R01) describes both the history of manufacturing operations at RMA and the administrative and regulatory compliance actions undertaken at RMA, including the FFA, RI/FS, and interim response actions (IRAs). The complete history of RMA is described in more detail in the Final Remedial Investigation Summary Report (RISR) (EBASCO 1992a/RIC 92017R01). In addition to the RISR, the nature

and extent of soils contamination at RMA is also addressed on a site-by-site basis in the Contaminant Assessment Reports (CARs) and Study Area Reports (SARs).

Of particular importance to the RI/FS, the FFA (EPA et al. 1989/RIC 89068R01) prohibits certain land use activities at RMA including residential development, consumption of game and fish taken at RMA, use of groundwater as a potable source, and agriculture activities (except for those related to erosion control or remediation). The agreement outlines specific goals for the RMA RI/FS including, among others, implementing IRAs, ensuring that the provisions of CERCLA are met, providing for a health assessment conducted by the Agency for Toxic Substances and Disease Registry (ATSDR), and ensuring that health-based remediation goals are met. The FFA also states that the goal for future land use at RMA is to set aside large areas of land as open space. On October 9, 1992, RMA was designated as a future National Wildlife Refuge (upon completion of cleanup), which significantly constrains potential future land use.

Following initial investigations, contamination sources were identified and initial source control actions were developed. Soils actions included applying fugitive dust emission controls to basins and removing portions of the Chemical Sewers System. In addition to the source control actions, and in accordance with the FFA, 13 IRAs were established for implementation prior to the ROD. These IRAs were designed to provide immediate containment or treatment of some of the more highly contaminated areas and thus minimize the potential for exposure to or migration of contamination. One of these IRAs included containing over 580,000 cubic years of Basin F sludge and contaminated soil to prevent contaminant migration.

During the course of the on-post RI, nearly 14,000 samples were collected, including more than 9,600 soil samples from more than 6,000 borings. Samples were analyzed for as many as 60 specific chemical analytes and were screened for hundreds of others. The RI results are presented in more than 230 reports that are summarized in the RISR (EBASCO 1992a/RIC 92017R01). Additional information gathered during the evaluation and implementation of IRAs

has also been used by both the Integrated Endangerment Assessment/Risk Characterization (IEA/RC) and the FS.

In addition to the analytical information collected through the drilling and sampling program, considerable amounts of nonanalytical information have been collected from both Army and Shell records, operations logs, and employee interviews. The qualitative information was used to supplement the quantitative information in the assessment of site risk and site remediation.

The bulk of the contamination is contained in the central sections of RMA in and around the manufacturing complexes, solid waste disposal areas, and liquid waste basins. Data from the RI regarding the levels and extent of contamination have been used in the IEA/RC assess risks and develop preliminary health-based cleanup criteria and in the FS to develop and evaluate remedial alternatives for RMA.

During the course of the FS, certain data needs were identified regarding verification of surficial soils contaminant levels, detections of fluoroacetic acid (FC2A) during the RI, screening of sites with potential agent presence, and previous sampling data. These additional data were necessary to more thoroughly develop and select the preferred alternatives for on-post soils. In addition, for those soils sites that interact with the structures medium, a need to determine whether treatment of structural material is necessary or feasible was identified. This data need is currently being addressed through the pilot demolition program, a program designed to evaluate structure sampling, decontamination, and demolition methods.

In 1989, the Army initiated the FS for the on-post operable unit at RMA. The FS developed a range of remedial alternatives in accordance with EPA guidance (EPA 1988a) and the NCP (EPA 1990). This range of alternatives, and the results of screening these alternatives based on effectiveness, implementability, and cost, were presented in the DSA report (EBASCO 1992b /RIC 92363R01), which was issued in final form on December 21, 1992.

As described in the DSA report, alternatives were developed and screened for each of the medium groups identified as posing an unacceptable risk to human health or biota. Both quantitative and qualitative criteria were used to evaluate risk and identify the appropriate remedial alternatives. During the DAA, the alternatives retained in the DSA report were analyzed in additional technical detail and were compared using the EPA criteria outlined in the NCP (EPA 1990) and CERCLA guidance (EPA 1988a and 1988b) to select a preferred alternative for each medium group.

Section 121(d) of CERCLA establishes a process for developing and selecting remedial actions that are protective of human health and the environment. For human health, remedial actions are defined as protective if they limit the excess lifetime cancer risk to between 10^{-4} and 10^{-6} for an individual potentially exposed to carcinogenic contaminants, and if they limit the adverse noncarcinogenic effects to an individual for a lifetime or partial lifetime exposure (EPA 1990 430(e)(2)). As part of the RMA RI/FS, the IEA/RC is being undertaken for both human and biotic receptors to determine protective risk-based exposure levels for the soils medium. Section 1.4 presents the results of the IEA/RC including the identification of contaminants of concern (COCs) for both humans and biota. In addition, Section 1.4 discusses the physical hazards associated with UXO and the acute chemical hazards associated with agent.

1.3 REMEDIAL ACTION OBJECTIVES

The purpose of the FS is to develop and select alternatives that are protective of human health and the environment. To determine which actions are warranted for RMA sites, the definition of protectiveness must be established. The NCP requires that the FS establish RAOs and preliminary remediation goals (PRGs), based on applicable or relevant and appropriate requirements (ARARs) and other directives, standards, or guidances to be considered (TBCs). This section explains the development of RAOs, and Section 1.4 summarizes the evaluation criteria for the soils medium at RMA, including the evaluation of PRGs, ARARs, and TBCs.

RAOs were developed on a medium-specific basis to focus the development, evaluation, and selection of remedial alternatives that minimize potential threats to human health and the environment. RAOs must be broad enough in scope to allow the development and evaluation of a range of remedial alternatives. RAOs for the soils medium were developed during the DSA based on the potential risks to human and ecological receptors from exposure to contaminated soils and sediment as well as the provisions of the FFA.

The RAOs identified for the soils medium are the following:

Human Health Protection

1. Prevent ingestion of, inhalation of, or dermal contact with soils or sediments containing COCs[1] in excess of on-post remediation goals.[2]

2. Prevent inhalation of COC[1] vapors emanating from soils or sediments in excess of on-post remediation goals[2] for the vapor pathway, as established in the on-post EA.

3. Prevent migration of COCs[1] from soils or sediments that may result in off-post groundwater, surface water, or windblown particulate contamination in excess of off-post remediation goals.

4. Prevent contact with physical hazards such as UXO.

5. Prevent ingestion of, inhalation of, or dermal contact with acute chemical agent hazards.

Ecological Protection

1. Ensure that biota are not exposed to COCs[1] in surface water, due to migration from soils or sediment, in concentrations capable of causing acute or chronic toxicity via direct exposure or bioaccumulation.

2. Ensure that biota are not exposed to COCs[1] in soils and sediments in concentrations capable of causing acute or chronic toxicity via direct exposure or bioaccumulation.

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[1] COCs are defined as those contaminants specifically identified through the on-post Human Health Risk Characterization and the Ecological Risk Characterization, and the off-post Endangerment Assessment. Reference to the EA process is intended to include the exposure assessment, the risk characterization, and the integrated EA.

[2] The development of preliminary and final remediation goals, in accordance with the NCP, is an ongoing process requiring continual evaluation of site-specific conditions and evolving health-based criteria and regulatory standards. Remediation goals may change as the FS progresses. Preliminary remediation goals are currently being established for the on-post and off-post operable units through the evaluation ARARs, human health risk-based criteria, Army regulations, the FFA, ecological risk-based criteria, ambient concentrations of naturally occurring or anthropogenic chemicals, and detection or remediation technology limits.

1.4 SOILS EVALUATION CRITERIA

In order to determine the protectiveness of a remedial alternative, two sets of soils evaluation criteria are used to determine when remedial actions are warranted at a site and the goals to be achieved by a remedial action. Site evaluation criteria (SEC) are used to determine which sites require remedial action and are evaluated as part of the DAA. As discussed in the DSA and summarized in Section 1.4.2, the SEC are based on an excess cancer risk for human health greater than 10^{-4}, a noncarcinogenic hazard index (HI) for human health of 1, a HI of 10 for biota, potential agent presence, and potential UXO presence.

Once the decision is reached to consider remedial actions, a remedial alternative is evaluated against the PRGs to determine its protectiveness. The PRGs, discussed in Section 1.4.1, are risk reduction goals that are set at an excess cancer risk of 10^{-6}, a human health noncarcinogenic HI of 1, and a biota HI of 1. The PRGs represent the preferred residual risk, although a remedial alternative is considered protective if the residual risk is between the PRGs and SEC.

Both the PRGs and SEC are based on ARARs, human health and biota risk-based criteria, Army regulations, ambient concentrations of naturally occurring or anthropogenic chemicals, and technical limitations. Since the development of PRGs and SEC considers ARARs, potential ARARs were compiled during the DSA to comply with Section 121(d) of CERCLA. Pursuant to this section, an ARAR is defined as "any standard, requirement, criterion, or limitation under any Federal environmental law ... or ... any promulgated standard, requirement, criterion, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard ... [that is] legally applicable to the hazardous substance or pollutant or contaminant or is relevant and appropriate under the circumstances of the release or threatened release" at the designated site.

Potential ARARs were identified according to the procedures outlined in the most recent EPA guidance (EPA 1988a,b) and the NCP (EPA 1990). The ROD will identify the ARARs that will be attained by the selected remedies as well as any federal or state ARARs that the selected

remedies will not meet. In circumstances in which an ARAR will not be attained, the ROD will also identify the waivers that will be invoked and the justification for invoking each waiver.

Potential chemical-specific ARARs pertinent to the soils medium were evaluated as part of the PRG identification process in the DSA. However, it was determined that chemical-specific ARARs for contaminants found in RMA soils do not exist. Location- and action-specific ARARs were also evaluated and are discussed in the DSA (Volume II) and the Technology Description Volume. Land disposal restrictions (LDRs) are considered potential action-specific ARARs for alternatives that involve off-post disposal of wastes regulated under the Resource Conservation and Recovery Act (RCRA).

In the absence of chemical-specific ARARs, human and ecological risk-based criteria are the primary sources of PRGs and SEC. The Human Health PRGs and SEC are based on PPLVs developed as part of the human health risk characterization portion of the IEA/RC, and the Biota PRGs and SEC are based on the probabilistic biota criteria (PBC) developed for the ecological risk characterization portion of the IEA/RC. Specifically, the Human Health PRGs are based on the industrial worker and biological worker exposure scenarios for the Open Space land use, as discussed in the Soils DSA (Volume I).

The results of the quantitative evaluations must be interpreted within the context of the inherent limitations and uncertainties of the overall endangerment assessment. The factors and assumptions contributing to the uncertainty of estimated risks include: limitations of the chemical database; the methods used to estimate exposure concentrations; uncertainties in human and biota exposure scenarios used in the risk assessment; uncertainties in the dose-response models assumed in developing toxicity estimates; and the uncertainties in the models and parameters used to characterize risks. Given these uncertainties, parameters were assigned reasonable but conservative values to ensure protectiveness of the exposed populations.

Principal threat criteria are also evaluated in the DAA to focus the most aggressive remedial actions on the areas with the highest levels of contamination. As discussed in Section 1.4.3, the principal threat criteria consist of a 10^{-3} excess cancer risk and a noncarcinogenic HI of 1,000, and are applied to areas exceeding the Human Health SEC.

1.4.1 Preliminary Remediation Goals

PRGs are the chemical-specific criteria that identify the remediation and treatment goals that are capable of achieving the RAOs defined above. PRGs were identified in the DSA step of the FS; however, as the FS progresses, PRGs may be modified or redefined as more information about the site and additional details on the performance of alternatives become available. Final remediation goals will be determined when the remedy is selected and the ROD is issued. The development of PRGs is an ongoing process requiring continual evaluation of site-specific conditions and evolving health-based and regulatory standards. Human Health PRGs include the following:

1. Achieve the reduction, elimination, or control of human exposure to COCs in residual contaminated soils exceeding the Human Health SEC so that the cumulative lifetime exposure risk does not exceed 10^{-6} for carcinogens (as a point of departure) or a HI of 1 for noncarcinogens.

2. Achieve the reduction, elimination, or control of biota exposure to Biota COCs in contaminated soils exceeding the Biota SEC for the most sensitive exposed species.

3. Achieve the overall remediation time frame goal for RMA of 10 to 30 years.

In accordance with the NCP (EPA 1990, Section 300.430(e)(i)), PRGs for human health and biota were identified after considering ARARs, human health risk-based criteria, factors related to technical limitations (e.g., detection limits or treatment limits), ambient concentrations of naturally occurring or anthropogenic chemicals, reasonable future land use scenarios, and ecological criteria. Table 1.4-1 lists the COCs and the Human Health and Biota PRGs. The lowest of the industrial worker and biological worker PPLVs for the Open Space future land use scenario were used to determine Human Health PRGs as discussed in the Soils DSA. The Biota PRGs are based on the probabilistic biota criteria (PBC) as discussed in the ecological risk

characterization portion of the IEA/RC (EBASCO 1992d/RIC 92275R02). Once the PBC have been revised as a result of the ongoing IEA/RC process, they will be incorporated into the DAA.

As discussed in the Soils DSA, the NCP (EPA 1990) states that the acceptable exposure levels for a carcinogenic compound are between 10^{-4} and 10^{-6}. Once a decision is reached to evaluate remedial actions (based on the SEC), the EPA (EPA 1991a) states a preference for cleanups to achieve the more protective end of the range (i.e., 10^{-6} excess cancer risk). As a result, the Human Health PRGs are established at a 10^{-6} excess cancer risk. However, an alternative that reduces the residual risk to within the 10^{-4} to 10^{-6} acceptable cancer risk range is considered protective even though PRGs are not achieved.

1.4.2 Site Evaluation Criteria

A total of 178 soil contamination sites were identified in the SARs (EBASCO 1989a-f), and two additional soil contamination sites were evaluated during the DSA. The first of these additional sites was the Basin F Wastepile, which was constructed in 1989 as part of the Basin F IRA. The second additional site was the Surficial Soils site (EBASCO 1991/RIC 91121R01), which included potential contamination outside the boundaries of the SAR sites. This investigation was summarized in the Final RISR (EBASCO 1992a/RIC 92017R01). In the DAA, a third site was also evaluated. As identified in the RISR, this site consists of soils beneath three buildings in North Plants with potential agent presence (EBASCO 1992a/RIC 92017R01).

1.4.2.1 Human Health SEC

The NCP (EPA 1990) indicates that " ... for suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} ..." The EPA guidance document, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (EPA 1991a), indicates that action generally is not warranted for sites with additive excess cancer risks less than 10^{-4}, and an HI less than 1 for noncarcinogenic contaminants. Therefore, the Human Health SEC are defined as the additive excess cancer risks of COCs equal to 10^{-4} and/or additive noncarcinogenic HIs equal to

1. For this version of the DAA, a boring-by-boring analysis was performed to identify the areas of each site, if any, that exceeded the SEC. Sites with contaminant concentrations that result in exceedances of these criteria are termed exceedance sites, and their contaminants and resultant volumes are referred to as exceedance COCs and exceedance volumes. Table 1.4-1 presents both the Human Health SEC, which are based on a 10^{-4} excess cancer risk and noncarcinogenic HI of 1, as well as the Human Health PRGs, which are based on 10^{-6} excess cancer risks. The Human Health SEC are based on the lowest of industrial and biological worker PPLVs.

1.4.2.2

The primary COCs for biota addressed in the ecological risk characterization portion of the IEA/RC were five organochlorine pesticides and mercury, which are widespread and bioaccumulative. The approach used for each of these COCs identified the maximum allowable tissue concentrations (MATC) for each target receptor, from which the PBCs were developed. For this version of the DAA, these PBC formed the biota SEC. The dose-based approach is being used in the ongoing ecological risk characterization portion of the IEA/RC for eight less-widespread and/or nonbioaccumulative chemicals for which risk was also evaluated. This approach incorporates toxicity reference values (TRVs), a similar concept to the reference dose values used in human health risk assessment, and the resulting dose-based criteria will be used in the DAA when available.

For this version of the DAA, the SEC are being applied on a boring-by-boring basis to identify biota exceedance areas. However, because of its inherently conservative assumptions, the boring-by-boring approach is neither a true representation of average exposure nor a realistic presentation of potential risks. The home range approach currently under development, which reflects a species' actual area of exposure to contaminated soils, will provide more realistic estimates of site-specific biomagnification and therefore more realistic PBC, which will be incorporated into future versions of the DAA.

The Biota SEC are based on the currently available PBC, and are set at 10 times the PBC (i.e., an HI of 10), as discussed in the ERC (EBASCO, 1992d/RIC 92275R02). Once the PBC have been revised as a result of the IEA/RC process, the revised values will be incorporated into the DAA. Table 1.4-1 presents the Biota SEC.

1.4.2.3 Potential UXO or Army Agent Presence

Any site that potentially contains UXO or Army agent, as identified in the Final RISR (EBASCO 1992a /RIC 92017R01), is also identified as an exceedance site. The Final RISR considered historical site usage and agent-screening investigations performed during the RI to identify UXO and agent sites.

1.4.2.4 SEC Basis of Values

In summary, the criteria for evaluating which sites require remedial actions are the following:

- Human Health SEC—Excess cancer risk greater than 10^{-4} and/or a noncarcinogenic HI > 1
- Biota SEC—HI > 10 for the PBC
- UXO Presence—Known, expected, or potential presence agent
- Agent Presence—Known, expected, or potential presence of agent

From the total of 181 sites, 111 sites have been identified as exceedance sites using these SEC, considering impacts to human health, impacts to biota, potential presence of UXO, and potential presence of agent.

Some areas at RMA that are known to be highly contaminated and/or that present special safety concerns based on historical information were not extensively sampled. Consequently, a qualitative assessment was conducted to identify areas of concern that were not addressed in the quantitative assessment. The qualitative assessment focused on the following areas: sites with potential agent or UXO presence, drum disposal sites, underground storage tanks (USTs), burn

sites, trenches, sanitary landfills, and spill sites. Additionally, the chemical database was re-evaluated to identify sites where exposure to tentatively identified compounds/unknowns and other chemicals not selected as COCs could pose potential unquantified risks. Results of the qualitative assessment were used to document qualitative risks for sites included in the current FS process to ensure all potential risk areas are considered in the FS and to evaluate the 70 FS no-action sites to identify any potential qualitative risk not considered in the determination of the no-action designation.

1.4.3 Principal Threat Criteria

In addition to the PRGs, Human Health SEC, and Biota SEC, the NCP concept of principal threat areas are evaluated for sites at RMA. The EPA fact sheet, A Guide to Principal Threat and Low-Level Threat Wastes (EPA 1991b), provides the following definitions of principal threats, low-level threats and source material, as well as providing guidance on determining the threat of a source material:

Principal Threats—

> ... those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. They include liquids or other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds. No "threshold level" of toxicity/risk has been established to equate to "principal threat." However, where toxicity and mobility of source material combine to pose a potential [excess] cancer risk of 10^{-3} or greater, generally treatment alternatives should be evaluated.

Low-level threats—

> ... those source materials that generally can be reliably contained and that would present only a low risk in the event of release. They include source materials that exhibit low toxicity, low mobility in the environment, or are near health-based levels.

Source material—

> ... material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or acts as a source for direct exposure. Contaminated groundwater generally is not considered to be a source material although non-aqueous phase liquids (NAPLs) may be viewed as source materials.

The guidance continues that—

> ... Determinations as to whether a source material is a principal or low-level threat waste should be based on the inherent toxicity as well as a consideration of the physical state of the material (e.g., liquid), the potential mobility of the wastes in the particular environmental setting, and the lability and degradation products of the material. However, this concept of principal and low-level threat waste should not necessarily be equated with the risks posed by site contaminants via various exposure pathways. Although the characterization of some material as principal or low level threats takes into account toxicity (and is thus related to degree of risk posed assuming exposure occurs), characterizing a waste as a principal threat does not mean that the waste poses the primary risk at the site. For example, buried drums leaking solvents into groundwater would be considered a principal threat waste, yet the primary risk at the site (assuming little or no direct contact threat) could be ingestion of contaminated groundwater.

Principal threats, as defined in EPA's Guide to Selecting Superfund Remedial Actions (EPA 1990), include the following:

- Areas contaminated with high concentrations of toxic compounds
- Liquids and other highly mobile materials
- Contaminated media (e.g., contaminated groundwater, sediment, soil) that pose a significant risk of exposure
- Media containing contaminants several orders of magnitude above health-based levels

The concept of identifying the principal threat wastes is to focus the most aggressive remedial actions on the areas of highest risk to human health and the environment. This is especially appropriate to RMA because many sites combine large areas of minimal or low-level contamination with small areas of high-level contamination, that fall within the definition of principal threats. EPA's Guide to Selecting Superfund Remedial Actions (EPA 1990) further explains this approach: "Areas on-site with contaminant concentrations several orders of

magnitude above these preliminary remediation goals are candidate areas for treatment. Areas on site with contaminant concentrations within several orders of magnitude of these preliminary remediation goal levels are candidate areas for containment."

However, the guidance continues, identification of sites or areas of sites as principal threats does not necessarily require treatment:

"Specific situations that may limit the use of treatment include:

- Treatment technologies are not technically feasible or are not available within a reasonable time frame
- The extraordinary volume of materials or complexity of the site make implementation of treatment technologies impracticable
- Implementation of a treatment-based remedy would result in greater overall risk to human health and the environment due to risks posed to workers or the surrounding community during implementation or
- Severe effects across environmental media resulting from implementation would occur.

Conversely, there may be situations where treatment will be selected for both principal threat wastes and low-level threat wastes." (EPA 1991).

Thus, the identification of the principal threat wastes does not exclude the treatment of soils with low-level threat wastes. Rather, the areas exceeding the principal threat criterion are targeted for aggressive treatment, if treatment is not impractical as outlined above, while the remainder of the site area that exceeds the Human Health or Biota SEC are targeted for less aggressive treatment, containment, or other engineering controls to reduce total site risk.

Since 10^{-4} is considered by guidance to be within the acceptable risk range, the principal threat criteria for RMA soils were established at a 10^{-3} excess cancer risk and a noncarcinogenic HI of 1,000, which is consistent with the above-referenced definition of principal threat wastes. These levels are compared to the Human Health PRGs and SEC in Table 1.4-1. This definition of principal threats level is consistent with the guidance because it is several orders of magnitude higher than the Human Health PRGs and SEC and because it allows an accurate assessment of

principal threat areas. In addition, if an area fails one of the other above-listed principal threat criteria, the area may be considered a principal threat regardless of established risk levels.

As a result of using the principal threat criteria, some alternatives developed in the Soils DSA were modified during the DAA to reflect treatment of the principal threat volumes using aggressive methods, while the remainder of the site is handled according to the original less aggressive treatment or containment approach (full treatment alternatives are also retained and evaluated). An example of this modification is the installation of a cap at Basin A. In the DSA, Alternative 6 consisted of containment of the entire site with a clay/soil cap. In the DAA, this alternative was replaced with Alternative 6a, which includes the thermal treatment of all principal threat volumes followed by containment of the remaining exceedance area with a clay/soil cap. This modification to the DSA alternative provides a significant reduction in long-term risk at the site and is a cost-effective way to reduce the overall risk of Basin A. Treatment alternatives that might be rejected in the DAA process due to excessive costs have now been modified to treat the areas of greatest risk at the sites while using containment or engineering controls to reduce risk over the majority of the site. In this way, principal threat criteria focus more of the available environmental remediation funds and effort at the most contaminated soils as they allow the remediation of less contaminated areas at less cost and effort.

1.5 CHARACTERIZATION AND GROUPING OF SOILS SITES

A total of 178 potentially contaminated soil sites were investigated during the RI. In addition, three sites have been added during the FS as a result of additional IRA and RI investigation efforts. Of the 181 sites investigated, 111 were determined to require further evaluation in the FS based on SEC described in Section 1.4.2. These 111 sites are organized into "exceedance categories" based on the soils evaluation methodology in the DSA. The four exceedance categories are as follows:

- Potential UXO Presence—Potential presence of UXO identified as the only SEC exceeded
- Potential Agent Presence—Potential presence of Army chemical agent identified as the only SEC exceeded

- Biota Exceedance—Exceedance of Biota SEC identified as the only SEC exceeded
- Human Health Exceedance—Exceedance of Human Health SEC, although portions of these sites may also potentially contain UXO, potentially contain agent, and/or exceed Biota SEC

The large number of RMA sites were addressed in the DSA using "medium groups", which are groups of sites within each exceedance category that are similar in site type and contamination patterns (e.g., sanitary landfills with metallic debris and rubbish). The grouping of sites was modified during the DAA so that the screened alternatives from the DSA could be applied to the subgroups of sites in each medium group. Table 1.5-1 is a list of the soils medium groups and subgroups that were developed based on the criteria outlined in Section 3.1.1.

1.6 DETAILING OF SOILS ALTERNATIVES

In keeping with the NCP (EPA 1990), the DAA evaluated the range of potentially effective, implementable, and cost-effective remedial alternatives that are retained in the DSA. These alternatives range from the "No Additional Action" alternative to various containment and treatment approaches.

The level of detail describing the component process options in the alternatives retained in the DSA was increased in the DAA to permit the detailed analysis of alternatives according to the evaluation criteria specified in EPA guidance (Executive Summary). However, design-level details regarding the operation of treatment processes are not developed at this stage of the FS process since they are not required to properly evaluate the alternatives against the seven DAA evaluation criteria.

In the DAA, the time frame to construct and implement each alternative is specified. The overall time frame includes the time to obtain needed equipment and specialists, obtain and construct alternative components, perform system startup and testing, operate the system until remedial goals are met, and demobilize the alternative (if necessary).

The level of detail and accuracy of cost estimates for each alternative is also increased in the DAA. The capital and operating costs include the following cost items:

- Direct capital costs including construction, equipment, and buildings
- Indirect capital costs including engineering, permit compliance, startup, and contingency costs
- Annual operating and maintenance costs including operating labor, maintenance material and labor, materials and energy, disposal, sampling/monitoring, administrative, permit compliance, replacement, and site review costs
- Long-term monitoring and maintenance costs including labor, materials, and replacement equipment

Since the DAA is the last step in the FS process leading to the ROD, the focus of the document includes a consideration of combined alternatives and integrated remedies (Section 3.0). For example, a central thermal desorption facility is considered in the DAA to take advantage of economies of scale when treating multiple sites, or the consolidation of soils from many sites under a single clay/soil cap in Basin A is considered to avoid the installation of multiple caps and cap monitoring requirements at scattered sites. Alternatives carried forward from the DSA were also modified or simplified in the DAA when the characteristics of the medium group or subgroup would allow. For example, sites without inorganic contamination do not require solidification after organic contaminants are removed by thermal desorption. In these cases, the thermal desorption/solidification alternative was modified to include thermal desorption only.

The DAA also considers additional alternatives that address principal threat volumes. For human health alternatives that consider principal threat treatment, the soil volumes representing an excess cancer risk of 10^{-3} and an HI of 1,000 are addressed by excavation and aggressive treatment, while the remaining site exceedance areas and exceedance volumes are addressed by engineering controls, containment, or other less aggressive treatment. The DAA also takes a consistent approach to the application of alternatives for human health and biota exceedance areas. For

example, where thermal desorption is considered for the human health exceedance volume, thermal desorption is also considered for the biota exceedance volume.

Table 1.4-1 Soils Site Evaluation Criteria and Preliminary Remediation Goals (in ppm)

Contaminants of Concern	Principal Threat	Human Health SEC	Human Health PRGs	Biota SEC	Biota PRGs
Aldrin	560	56	0.56	0.68	0.068
Benzene	11,000	1,100	11	–	–
Carbon Tetrachloride[1]	2,200	25	2.2	–	–
Chlordane[1]	260	3.1	0.26	–	–
Chloroacetic Acid[1]	74,000	74	74	–	–
Chlorobenzene[1]	750,000	750	750	–	–
Chloroform[1]	49,000	350	49	–	–
DDE	1,300	130	1.3	0.20	0.020
DDT[1]	1,300	26	1.3	1.4	0.14
DBCP	240	24	0.24	–	–
1,2-Dichloroethane	3,400	340	3.4	–	–
1,1-Dichloroethane	550	55	0.55	–	–
Dicyclopentadiene[1]	NA	1,200	1,200	–	–
Dieldrin	400	40	0.40	0.83	0.083
Endrin	15,000	15	15	0.029	0.003
Fluoroacetic Acid[1,2]	180	2.0	2.0	–	–
HCCPD[1]	NA	1,300	1,300	–	–
Isodrin[1]	3,400	3.4	3.4	–	–
Methylene Chloride[1]	41,000	2,200	41	–	–
1,1,2,2-Tetrachloroethane	1,500	150	1.5	–	–
Tetrachloroethylene[1]	5,900	370	5.9	–	–
Toluene[1]	NA	6,800	6,800	–	–
Trichloroethylene	35,000	3,500	35	–	–
Arsenic	5,300	530	5.3	16.5	1.65
Cadmium[1]	66,000	480	66	–	–
Chromium[1]	10,000	40	10	–	–
Lead[1]	NA	1,900	1,900	–	–
Mercury[1]	470,000	470	470	0.99	0.099

DDE dichlorodiphenylethane
DDT dichlorodiphenyltrichloroethane
DBCP dibromochloropropane
HCCPD hexachlorocyclopentadiene
ppm parts per million
PRG Preliminary Remediation Goal
SEC Site Evaluation Criteria
1 SEC based on noncarcinogenic PPLV.
2 SEC based on CRL.

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Human Health Exceedance Category

- Basin A Medium Group
- Secondary Basins Medium Group
  - Former Basin F Subgroup
  - Basin F Exterior Subgroup
  - Secondary Basins Subgroup
- Basin F Wastepile Medium Group
- Sewer Systems Medium Group
  - Chemical Sewers Subgroup
  - Sanitary/Process Water Sewers Subgroup
- Disposal Trenches Medium Group
  - Complex Trenches Subgroup
  - Shell Trenches Subgroup
  - Hex Pit Subgroup
- Sanitary Landfills Medium Group
- Lime Basins Medium Group
  - Section 36 Lime Basins Subgroup
  - Buried M-1 Pits Subgroup
- South Plants Medium Group
  - South Plants Central Processing Area Subgroup
  - South Plants Ditches Subgroup
  - South Plants Tank Farm Subgroup
  - South Plants Balance of Areas Subgroup
- Buried Sediments/Ditches Medium Group
  - Buried Sediments Subgroup
  - Sand Creek Lateral Subgroup
- Undifferentiated Medium Group
  - Section 36 Balance of Areas Subgroup
  - Burial Trenches Subgroup

Biota Exceedance Category

- Surficial Soils Medium Group
- Lake Sediments Medium Group
- Ditches/Drainage Areas Medium Group

Potential Agent Presence Category

- Agent Storage Medium Group
  - North Plants Subgroup
  - Toxic Storage Yards Subgroup

Potential UXO Presence Category

- Munitions Testing Medium Group

2.0 MEDIA INTERACTIONS

This section describes the interaction between alternatives developed for the soils medium and those developed for the water and structures media, as well as the cross-media impacts of soils remediation on the biota and air media that are not contaminated but may be affected by soils remediation. This interaction must be carefully evaluated to ensure that all alternatives are protective of human health and the environment. In the following sections, the interactions between water, structures, biota, and air media with the soils medium are described. As explained in the DSA, both the air and biota media are considered in the evaluation of alternatives for the soils, water, and structures media. However, alternatives were not specifically developed for air and biota media since they are impacted by the other three media.

2.1 WATER/SOILS INTERACTION

Interactions between soils and water include impacts of soils alternatives on both surface water and groundwater, as well as the impact of certain groundwater alternatives upon the overlying soils.

2.1.1 Surface Water Interactions

Soils interactions with surface water are relatively direct since areas with contaminated soils in contact with surface water are readily available for transfer of contaminants. The sediment contamination in the lakes in Sections 1 and 2 as well as the Havana Street Ponds in Section 11 has resulted largely through the surface water transport of contaminants and contaminated soils. Soils alternatives were developed to directly address these contaminated sediments (Section 7), and soils alternatives in the South Plants area also address the future reduction of contaminated runoff from soils in contaminated areas. The reduction of future impact of contaminants in the Havana Ponds is outside the scope of this FS, since the sources do not originate on RMA. However, the pond sediments are addressed in the Lake Sediments discussion (Section 7) in the Soils DAA.

2.1.2 Groundwater Interactions

The interactions between soils and groundwater at RMA are complex due to the number of sites potentially contributing to multiple groundwater plumes. The use of groundwater at RMA is restricted by the FFA, which limits the exposure of humans to contaminated groundwater. In addition, three groundwater systems have been installed on the boundaries of RMA to intercept and treat contaminated groundwater. As such, the soils RAOs evaluate the migration of contaminants from soil to groundwater that may result in off-post groundwater contaminant concentrations in excess of off-post remediation goals.

Certain soils alternatives directly impact groundwater alternatives and vice-versa. Furthermore, alternatives that involve excavation in areas of high groundwater tables require the installation of dewatering wells and the treatment of extracted water at the CERCLA Wastewater Treatment Plant. Conversely, groundwater dewatering alternatives lower water tables and may reduce the need for dewatering related to soils alternatives (although area-wide dewatering may take many years, and soils remediation may be required before this is accomplished). In situ soil flushing alternatives require the controlled pumping, treatment, and reinjection of solutions, which could require the modification of existing groundwater extraction and treatment systems. However, groundwater pump-and-treat alternatives could be integrated with soil flushing alternatives. In addition to in situ flushing, other processes that form part of various soils alternatives generate liquid sidestreams requiring treatment. Some of these processes, e.g., soil washing, have the liquids treatment unit built into the treatment system, and costs for treating the liquid sidestream are included in the overall cost of the process. Others, e.g., in situ radio frequency (RF) heating, create liquid sidestreams that must be treated on post prior to discharge. Soil and groundwater interactions such as these are addressed as they occur in the evaluation of alternatives (Sections 5 through 19), and the Technology Description Volume provides a detailed discussion of the systems themselves.

2.2 STRUCTURES/SOILS INTERACTION

Unlike groundwater/soils interactions, structures alternatives are closely tied to soils alternatives because most of the structures at RMA are located in areas of soils contamination. Accordingly, if a landfill disposal or treatment alternative is selected for contaminated soils associated with structures, the structures have to be demolished and removed to reach the underlying soils. If an in-place containment alternative is selected for the soils medium, the foundation and structural debris left in place could be covered with the cap. Alternately, if the No Additional Action or Institutional Controls alternative is selected for soils underlying structures, the structures may still be demolished in accordance with the alternative selected in the Structures DAA.

Due to economies of scale for all direct treatment processes, centralized facilities are to be constructed for the common treatment of soils from multiple medium groups (Section 3.1.2). These large facilities require from 1 to 2 years to design and construct, during which time structures can be removed from the site. Many of the planned and ongoing removal activities for process equipment, non-process equipment, materials containing polychlorinated biphenyls (PCBs) and asbestos-containing materials (ACM) require many months to complete. These efforts are currently in the planning stages or are underway. In addition, some structures demolition alternatives include salvage, which could take additional time. This delay may not impact remediation if soils from sites not in proximity to structures are processed first, allowing additional time for structures remediation. The phasing of remedial activities will be determined in the remedial design phase (following the ROD) to match available funding and to maximize efficiency.

2.3 BIOTA/SOILS INTERACTIONS

The potential health impacts of soils contamination on biota are being evaluated through the ecological risk characterization portion of the IEA. Soils alternatives are evaluated to specifically address areas that exceed risk-based criteria for humans and biota or potentially contain agent and UXO. In addition to the toxicological issues, biota are also impacted through the modification or elimination of habitat resulting from soils remediation. Wildlife management and habitat

management have been and continue to be important considerations in the selection of remedial strategies, particularly since RMA is to become a National Wildlife Refuge. While vegetation values over portions of RMA may not be excellent, RMA continues to maintain one of the largest undisturbed wildlife populations along the Rocky Mountain front range. Much of this is due to the lack of human activity and intervention, large amounts of open space, and use restrictions specifically designed to benefit wildlife. Remedial activities at RMA, unless properly managed, could threaten these populations through the disruption of habitat, increase in human interaction, and elimination of areas for wildlife activity.

To account for habitat values and wildlife needs, the Army has requested the technical assistance of the U.S. Fish and Wildlife Service (USFWS). The USFWS is performing habitat and vegetation surveys to determine ways to minimize habitat and wildlife disruption. In addition, the USFWS is preparing a refuge management plan that, when complete, will indicate areas that should be revegetated to a certain habitat value. Because RMA was recently designated a National Wildlife Refuge, the Army is attempting to minimize areas that will have restrictions to habitat or wildlife following remediation.

2.4 AIR/SOILS INTERACTIONS

As defined in the DSA, the air medium is considered an impacted medium, one which will be protected through the selection of appropriate soils, water, and structures alternatives. Air ARARs are evaluated as part of the ARARs evaluation of alternatives developed for the three contaminated media. All of the selected alternatives comply with air ARARs.

To ensure that soils alternatives meet air ARARs, an air model was developed for RMA by Shell/Morrison-Knudsen Engineering (MKE), with input from EBASCO and the Army. The model is based on air monitoring data collected from the Comprehensive Monitoring Program (CMP). This model, capable of addressing all alternatives developed in the DSA, can predict downwind concentrations at different distances from the proposed source. The anticipated feed concentrations and feed rates were evaluated based on the location of a centralized air monitoring

facility. The model was then used to determine what secondary treatment or vapor/dust controls are required to achieve air ARARs.

3.0 METHODOLOGY

This section presents a summary of the methodology used during the DAA to evaluate, compare, and select alternatives for the soils medium. In the DAA, the retained alternatives from the DSA are described in greater detail prior to being evaluated according to criteria set forth in the NCP (EPA 1990a). These criteria are described in detail in the Executive Summary Volume. Section 3.1 describes how the medium groups developed in the DSA were analyzed in greater detail, and how the subgroups are developed based on a number of criteria. In addition, Section 3.1 introduces the idea of centralized treatment and containment facilities. Section 3.2 briefly describes how seven of the nine EPA evaluation criteria for the DAA are used to evaluate each alternative for each subgroup. The remaining two criteria are to be evaluated as part of the Proposed Plan. Finally, Section 3.3 describes how the detailed alternatives are compared and how a preferred alternative is selected for each subgroup or medium group.

3.1 DETAILING OF ALTERNATIVES

In the DSA, medium groups were developed to minimize the repetition of developing alternatives for sites with similar contaminants, site types, and waste disposal criteria. The use of the medium-group approach was appropriate for developing and screening alternatives using the evaluation criteria of effectiveness, implementability, and cost.

In the DAA, however, a more detailed evaluation is required for the alternatives applied to each site. The concept of combining sites into medium groups still applies, since many sites are similar enough for a single group of alternatives to apply, even though the medium groups are to be evaluated on a more detailed basis. Section 3.1.1 describes how the medium groups were re-evaluated during the DAA and presents a list of the subgroups that were developed as a result of that re-evaluation. Because many of the alternatives for many of the medium groups are similar or contain similar technologies, the concept of constructing and using large, centralized facilities for treatment and containment is thoroughly evaluated in the DAA. Accordingly, Section 3.1.2 presents the details of the centralized treatment facilities and Section 3.1.3 the details of centralized containment facilities.

3.1.1 Evaluation of Medium Groups

Sixteen soils medium groups were developed during the DSA. The South Plants-Biota and South Plants Medium Groups were combined in the DAA due to their spatial proximity and similar contamination patterns. Eight of these 15 medium groups were then further subdivided into subgroups (seven of the medium groups do not contain subgroups) to achieve a higher level of similarity between sites, thereby making the evaluation of alternatives more effective. A total of 20 subgroups are developed based on exceedance sites with similar contaminant types or concentrations; physical or depositional characteristics; the results of IRAs; and interactions with structures or groundwater plumes. Therefore, the DAA considers 27 medium groups/subgroups (Table 3.1-1). Each site was evaluated to determine the applicability of remedial alternatives to that particular site. Due to the increased level of detail and specificity required in this phase, chemical or physical variations between sites within the same medium group were used to develop subgroups. Depending on site size, location, physical characteristics, and contamination pattern, these subgroups may contain one or several sites. The following paragraphs describe the DAA site characterization methods.

Additional site characterization, involving collection of information from the CARs, HHEA report (EBASCO 1990/RIC90277R05,06), and Phase I and Phase II FS data collection reports, was performed to provide sufficient information for evaluating the applicability of the retained alternatives to each site in a medium group. The site characteristics that govern the detailed analysis of alternatives and that were used to develop subgroups fall into nine general criteria, which are described as follows:

- Depth of contaminated soil—This criterion is evaluated since the depth of contamination may limit the suitability of particular remedial technologies. For example, technologies such as surface heating are effective for shallow contamination intervals.

- Driver Contaminants—The types of contaminants that comprise the exceedance volumes influence the selection of the preferred alternative. A primary remedial technology should therefore be selected for the most prevalent contaminant(s). A secondary treatment system or systems can be used for the remainder of the contaminants. In some cases, however, one treatment technology may provide effective remediation for all contaminants

detected at the site. In addition, the contaminants comprising the principal threat volumes are evaluated since the principal threat volumes are targets for treatment.

- Depth to Groundwater—Thickness of the vadose zone varies across the site, and treatment technologies may require a minimum thickness for installation and function of system. For example, in situ vitrification and RF heating require a minimum unsaturated soil thickness to operate.

- Major Soil Type—A total of 10 soil units that have been identified at RMA were divided into four soil types based on texture, clay content, and soil permeability for the purpose of evaluating subgroups. Soil types may increase or reduce treatment effectiveness. For example, soil venting is more effective on a sandy loam than on a clay loam due to the increased porosity and permeability of a sandy unit.

- Soil/Groundwater Interactions—Soil/groundwater interactions are evaluated at each site to assess the potential impacts of soils alternatives on groundwater alternatives. Sites are identified that might impact remediation of groundwater plumes during soils remedial actions.

- IRAs—IRAs that have been or are being performed at sites are identified and their actions summarized. Sites with IRAs may not need further remediation if the IRA is determined to provide long-term protection of human health and the environment.

- Site Configuration—Site shapes vary and are categorized as either square to oblate or extremely narrow. Extremely narrow sites such as ditches are not obstructed by structures, but are not favorable locations for access controls like habitat modifications.

- Agent/UXO Presence—Agent and/or UXO may be present along with human health or biota COCs at some of the sites. Sites are identified that potentially contain agent and/or UXO based on historical usage of the site in accordance with the Final RISR (EBASCO 1992a/RIC92017R01). Additional FS data collection programs are ongoing to further refine the extent of agent and UXO.

- Site Type/Usage—Each site has been evaluated for site type or usage, and eight categories were developed in the Final RISR (EBASCO 1992a/RIC92017R01). The site type/usage categories include surface soils/windblown; ordnance testing and disposal; spills/isolated; lake sediments, ditches, and ponds; basins or lagoons; buildings, equipment, and storage; sewer systems; and buried waste.

Sections 5 to 19 present the characteristics of the 27 medium groups/subgroups. Figure 3.1-1 shows the locations of the human health and biota exceedance areas, as well as the principal threat areas, for all of the medium groups. The principal threat areas are located in the South

Plants, in Section 36, and in the vicinity of Basin F. Figure 3.1-2 presents the areas potentially containing agent and/or UXO.

3.1.1.1 Evaluation of Fluoroacetic Acid Data

In the DSA, large exceedance volumes were calculated due to detections of FC2A. These detections, obtained during the Phase II RI, have been technically questioned due to new information regarding FC2A and the laboratory method used during the RI. FC2A is a highly toxic noncarcinogen, having a human health PRG of 0.24 parts per million (ppm) (Table 1.4-1).

The laboratory method used during the Phase II RI to test for FC2A cannot distinguish between FC2A and formic acid, a naturally occurring organic acid that is a breakdown product of certain plants. Formic acid is not considered a risk to human health or biota due to its low toxicity and ubiquitous nature. Therefore, all samples that indicated the presence of FC2A are now suspect. New analytical methods have been developed to analyze for FC2A without formic acid interference and are being used in the ongoing FS Volume Refinement Program (EBASCO 1993/RIC93061R02). The current field program will be used to confirm the presence or absence of FC2A contamination.

FC2A is listed in the RMA Chemical Index (EBASCO 1988) but no evidence of its use, production, or disposal at RMA is reported. FC2A has been suggested as a possible byproduct or degradation product associated with nerve agent manufacture or release, but FC2A has not been identified in association with the production of sarin or GB. Sarin hydrolyses in the environment to form isopropylmethylphosphonic acid (IMPA), isopropylmethyl phosphonate, methylphosphonic acid (MPA) and, ultimately, phosphate. Fluorine present in sarin is ionized to fluoride during the initial hydrolysis by water.

A potential source of FC2A at RMA is the limited use of its sodium salt, sodium fluoroacetate, as a rodenticide. Known as Compound 1080, Fractol, or Yasoknock, sodium fluoroacetate was formerly registered for use in controlling rats. The salt is extremely toxic to rats, but also to man

and other mammals. The use of FC2A as a rodenticide is unlikely to result in the uniform, widespread, low-level concentrations reportedly detected in RMA soils, however. Both FC2A and its sodium salt are highly soluble in water. Under normal environmental pH conditions, the dissociated anionic fluoroacetate species, or fluoroacetate salt, will predominate over FC2A.

Moreover, only limited information is available on the environmental transport and fate of FC2A. Following release into the environment, fluoroacetate is nonvolatile, and consequently will not be volatilized from soil or surface water into air. The high solubility of both the acid and sodium salt indicates a limited potential for adsorption to soils and correspondingly high mobility in surface and groundwater. Similarly, given the soluble nature of FC2A, bioconcentration is not expected (Gosselin 1976). Fluoroacetate is slowly degraded by soil bacteria, and does not usually persist for periods more than 2 months (David and Gardiner 1966).

FC2A is therefore not considered a COC for the Soils DAA. The impacts of the removal of the FC2A exceedance volume reduces the combined human health and biota exceedance volumes from 9.0 million to 8.2 million cubic yards (Figure 3.1-3). The results of the FS Soil Volume Refinement Program will be reviewed and incorporated into future versions of the DAA report.

3.1.2 Centralized Treatment Facilities

In the DSA, alternatives were developed and screened based on individual medium group volumes and areas. In the DAA, attention was given to recognizing economies of scale wherever possible. After reviewing the retained alternatives from the DSA, it became obvious that most of the retained alternatives included common treatment processes such as soil washing, thermal desorption, incineration, and solidification. To maximize economies of scale and minimize site preparation costs at each site, centralized treatment facilities were developed for the treatment processes mentioned above. These facilities include single or multiple treatment units sized to handle the combined soils from all medium groups with that treatment process as an alternative.

For example, instead of providing facilities and setup for 13 small, transportable thermal desorption units, one large facility is constructed in a centralized location for treatment of all the soils from the 13 subgroups for which thermal desorption could potentially be selected. Treatment rates and retention times are varied as required to achieve PRGs. The cost of treatment for each of these subgroups is based on a prorated portion of the cost of the centralized facility based on the quantities treated from that subgroup. This economy of scale is only valid based on the assumption that all 13 subgroups do actually select thermal desorption as the preferred alternative. However, these treatment costs are adequate to estimate DAA alternative costs and are within the accuracy requirements of the DAA according to EPA criteria. Following the selection of preferred alternatives for each medium group, the actual volumes to be addressed by each of these facilities can be more accurately projected. Therefore, the costs for these facilities are adjusted in Section 20 to better reflect the volumes that they are expected to handle (and consequently the unit prices).

The final siting and sizing of these facilities is an issue to be determined in the remedial design phase, which follows the issuance of the ROD. Due to new advances in technology or increases in throughput by existing systems, the number of treatment units and the type of system may be changed based on final estimates of soil volumes to be treated.

3.1.3 Centralized Containment Facilities

Much like the centralized treatment facilities described in Section 3.1.2 above, centralized containment facilities are developed for the DAA. A central RCRA landfill is developed containing separate landfill cells for hazardous and nonhazardous waste as discussed in Section 6.5 of the Technology Description Volume. The costs for landfilling for all medium groups are prorated based on the volume to be landfilled in the centralized facilities.

In order to maximize available habitat, minimize the amount of low-permeability soils required for capping, and minimize the areas requiring long-term monitoring and maintenance, consolidation is used extensively in the DAA to contain contaminated soils. Consolidation is the

movement of soils from areas of low contamination to areas with similar or higher levels of contamination for incorporation into a single capped area. Two locations are evaluated as potential sites for consolidation: Basin A and the South Plants Central Processing Area. In the case of Basin A, between 1.2 and 1.8 million cubic yards of soil are needed as grading fill prior to completing a cap. Using soils from other sites containing low levels of contamination as grading fill serves multiple purposes. It removes contaminated soils from many sites, allowing unrestricted access to the sites by both humans and biota for the majority of RMA, and is a cost-effective use of soils since it both minimizes the total surface area to be capped and does not require the importation of between 1.2 and 1.8 million cubic yards of clean fill to achieve appropriate drainage of the overlying cap for Basin A. If clean fill is used to achieve grade, it is considered to be tainted because it will have been consolidated with contaminated soils. An added benefit is that any contaminated leachate from contaminated soils placed in Basin A is removed at the Basin A Neck IRA. Consolidation in Basin A can be accomplished even if alternatives other than the caps/covers alternative is selected for Basin A since untreated soils may still require containment for biota, agent, or UXO considerations. In the case of the South Plants Central Processing Subgroup, approximately 500,000 cubic yards of soils are required to achieve the design grades.

As with centralized treatment facilities, the final sizing and siting of the facility will be determined in the remedial design phase, which follows the issuance of the ROD. Based on estimated quantities at that time, the unit price could change due to the number of cells to be constructed in the landfill or to the additional clean fill necessary to bring the consolidated area or areas up to final design grade prior to the installation of the cap.

3.2 EVALUATION OF INDIVIDUAL ALTERNATIVES

During the DSA, the potential alternatives were developed and screened based upon three criteria, effectiveness, implementability, and cost, to eliminate alternatives that did not achieve these criteria. Through the application of the three screening criteria, the number of alternatives retained for the DAA was reduced. Figures 3.2-1 through 3.2-15 portray the results of the DSA

screening. In the DAA, these retained alternatives are again evaluated and compared, although at a much more detailed level.

In Chapters 5 through 19, the remedial alternatives appropriate to each medium group are evaluated. Since the subgroups in any medium group do not necessarily exhibit the same remedial requirements, the full range of alternatives retained in the DSA may not necessarily be appropriate for all of the subgroups. For example, the Burial Trenches Subgroup does not have any exceedance volume for organochlorine pesticides (OCPs), or volatile organic compounds (VOCs). Therefore, the treatment alternatives retained for the Buried Sediments/Ditches Medium Group that address organic contaminants (Alternative 13a: Direct Thermal Desorption (Direct Heating) and Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating)) are not evaluated for the Burial Trenches Subgroup.

For each medium group or subgroup, each alternative is analyzed using the seven DAA evaluation criteria described in Section 3.2 of the Executive Summary Volume. State and community acceptance, which are acknowledged in the evaluation of implementability, are not formally evaluated at this stage of the FS process, but are to be evaluated as part of the Proposed Plan. The site-specific considerations described in Section 3.3 of the Executive Summary Volume are also discussed. The results are presented in the evaluation tables in each chapter.

3.3 SELECTION OF PREFERRED ALTERNATIVES

Once the alternatives for each subgroup have been individually analyzed based on the seven evaluation criteria, the alternatives are compared first by the threshold criteria, compliance with ARARs and overall protection of human health and the environment. Any alternative that fails to be protective of human health and the environment is dropped from further consideration. Any alternative that cannot comply with location- or action-specific ARARs and also fails to qualify for a waivers available under CERCLA is also dropped from further consideration. The consideration of these two factors foremost is based on the statutory requirements of the NCP.

The remaining protective and ARAR-compliant alternatives are then compared using the five balancing criteria: long-term effectiveness, TMV reduction, short-term effectiveness, implementability and cost. Preliminary determinations are made as to which alternatives represent permanent solutions, use treatment technologies to the maximum extent practicable, and are cost effective. The relative preference of alternatives is established by evaluating the extent to which each alternative satisfies the requirements of the balancing criteria and the site-specific considerations identified in Section 3.2 of the Executive Summary Volume.

Depending on site characteristics and level of toxicity, the balancing criteria may vary in their relative importance. For example, for a very large volume of material that is only marginally above health-based risk levels, processing capacity may limit the implementability of treatment options, and the cost of aggressive treatment may be prohibitive. In this case, implementability and cost are the most important balancing criteria, and the remaining questions of long-term effectiveness, TMV reduction, and short-term effectiveness have relatively less impact on the comparison of alternatives. The selection of preferred alternatives also considers the short-term impacts on worker health and safety during remedial actions, particularly those involving excavation, against the TMV reductions. In instances where the short-term risks result in a greater overall risk to workers or the environment, the short-term effectiveness has a greater impact than TMV reduction.

In addition to the comparison of the soils alternatives, any groundwater or structure interactions with soils that impact the overall remediation of the site are indicated. For example, Alternative 13: Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification) when applied to the South Plants Central Processing Subgroup requires the demolition and removal of structures prior to the excavation of soils above PRGs.

The logic used in the selection of the preferred alternative for each subgroup is presented at the end of each subgroup discussion as part of the comparative analysis of alternatives.

Table 3.1-1 Summary of Medium Groups and Subgroups

Medium Group	Subgroup	Sites	Description
Munitions Testing	–	CSA-2c CSA-2d ESA-1a ESA-1b ESA-1c ESA-1d ESA-4a ESA-4b	These sites have been grouped together based on similar site histories and uses, and are considered exceedance sites based on the potential presence of HE-filled UXO. The sites are predominantly located in the eastern portions of RMA, and were used for testing or destruction of nonchemical munitions. These sites typically contain slag, debris, and potential UXO in the upper 1 ft of soil and therefore present physical hazards. Site ESA-4a may contain UXO at depths of up to 6 ft since it was an impact area for mortars. COC concentrations were not detected above Human Health SEC at any of the sites; however, mercury exceeding the Biota SEC was detected at an isolated location.
Agent Storage	North Plants	NPSA-3 NPSA-5 NPSA-6 Building 1601[1] Building 1606[1] Building 1607[1]	Sites within this subgroup are those that have potential agent presence but do not contain human health exceedances except as isolated detections, and are located in the North Plants GB manufacturing area. These sites are presumed to contain agent because of historical use of agent and the presence of agent breakdown products, although agent itself has not been detected. Isolated detections of COCs exceeding their Human Health SEC include arsenic and chromium. COCs exceeding their Biota SEC include dieldrin, arsenic, and mercury.
	Toxic Storage Yards	ESA-3a ESA-3b ESA-3c ESA-3d ESA-3e ESA-3f ESA-3g ESA-3h ESA-3i	This subgroup contains sites that have potential agent presence but do not contain human health exceedances except as isolated detections. These sites are located in the storage areas in the eastern portion of RMA. These sites are presumed to contain agent because of historical use and the presence of agent breakdown products, although agent itself has not been detected. The only COC in the soil exceeding the Human Health SEC is CLC2A.

Table 3.1-1 Summary of Medium Groups and Subgroups

Medium Group	Subgroup	Sites	Description
Lake Sediments	–	NCSA-7 SSA-1b SSA-1c SSA-1e SSA-5b	Sites within this medium group include sediments from lakes located in the southern portion of RMA and sediments from the North Bog, and were grouped together based on the potential risk they present to biotic receptors. Contamination has resulted from the influx of suspended solid- or dissolved-phase contaminants transported to the lakes by surface water or groundwater. Isolated exceedances of Human Health SEC include chlordane and chromium. COCs in the sediment exceeding the Biota SEC are include predominantly OCPs.
Surficial Soils	–	NCSA-1g Surficial Soils Survey	This medium group consists of areas of contamination above Biota SEC outside the SAR sites. Affected soil contains OCPs, and was investigated to a depth of 2 inches.
Ditches/Drainage Areas	–	CSA-2b ESA-6c NCSA-1c NCSA-1d NCSA-1f NCSA-2d NCSA-5d NCSA-8b NPSA-8c NPSA-9f SSA-2a SSA-2c WSA-1f	Exceedance sites within this medium group have various disposal and release histories, and are contaminated with low levels of OCPs at concentrations above Biota SEC.
Basin A	–	NCSA-1a NCSA-1e	This medium group is comprised of two sites within the Basin A high-water line. Basin A contains soils and sediments that were in contact with organic and inorganic contaminants from manufacturing wastewater discharged to the basin. The medium group is also characterized by the potential presence of agent and agent-filled UXO. COCs detected above the Human Health SEC are primarily OCPs. Individual subgroups were not developed for this medium group.

Table 3.1-1 Summary of Medium Groups and Subgroups

Medium Group	Subgroup	Sites	Description
Basin F Wastepile	–	Basin F Wastepile	This medium group consists of the Basin F Wastepile that was formed as a result of the Basin F Groundwater IRA. The IRA has included the transfer of Basin F liquids to temporary storage tanks, excavation of Basin F soils from below the original asphalt liner, and final grading, capping, and revegetation of the excavated area. The Basin F Wastepile consists of the excavated sediments and soils that are contaminated with high levels of organic compounds, arsenic, and metals at concentrations above the Human Health SEC. The concentrations of organics are inferred to be on the order of 1,000 to 10,000 ppm. This material also contains elevated levels of salts due to the high chloride contents in wastewater stored in the former Basin F.
Secondary Basins	Secondary Basins	NCSA-2a NCSA-2b NCSA-5a	Sites within this subgroup consist of four liquid disposal basins (Basins B, C, D, and E) that collected overflow water from Basin A. These sites are expected to contain somewhat elevated levels of salts resulting from the storage of wastewater with high chloride content. COCs detected in the soil above the Human Health SEC include OCPs.
	Former Basin F	NCSA-3	The former Basin F site consists of the former basin area, including the area below the Basin F Wastepile. Basin F received wastewaters through the chemical sewer system, and the site is expected to contain somewhat elevated levels of salts due to the high chloride content in the wastewater. COCs remaining in the soil exceeding the Human Health SEC include OCPs and CLC2A.
	Basin F Exterior	NCSA-4a NCSA-4b	Sites within this subgroup are adjacent to the former Basin F, and consist of surficial soils and a deep well disposal facility with associated piping. COCs in the soil exceeding the Human Health SEC include OCPs.
Sewer Systems	Sanitary/Process Water Sewers	NCSA-8a SPSA-11 SPSA-12 WSA-7a	Sites within this subgroup consist of sanitary and process water sewers. Soils around these sewer lines predominantly contain COCs exceeding the Biota SEC. An isolated detection of chromium was the only exceedance of the Human Health SEC. COCs exceeding the Biota SEC include aldrin, dieldrin, and mercury.

Table 3.1-1 Summary of Medium Groups and Subgroups

Medium Group	Subgroup	Sites	Description
	Chemical Sewers	CSA-3 NCSA-6a NCSA-6b NPSA-1 SPSA-10	Sites within this subgroup consist of chemical sewers. COCs in the soil exceeding the Human Health SEC (including maximum concentration and depth) include OCPs, volatiles, CLC2A.
Disposal Trenches	Complex Trenches	CSA-1c	This subgroup is characterized by trenches or pits that were filled with trash and manufacturing/military wastes. Wastes are suspected to consist of drums of solid and liquid material, wood, glass, metal, laboratory and manufacturing equipment, and miscellaneous material. This subgroup is further characterized by the potential presence of agent and agent-filled UXO.
	Shell Trenches	CSA-1a	This subgroup is characterized by trenches or pits that were filled with trash and manufacturing/military wastes in the area of the Shell Trenches. Wastes are suspected to consist of drums of solid and liquid material. IRA activities at this site have consisted of the placement soil cap across the entire site and a vertical barrier surrounding the site.
	Hex Pit	SPSA-1f	This site was historically used for disposal of residual materials resulting from the production of HCCPD (hex bottoms). This material was buried in thin-gauge caustic barrels and in bulk.
Sanitary Landfills	–	CSA-1d ESA-2b SSA-4 WSA-2 WSA-3c WSA-5a WSA-5c WSA-5d	This medium group consists of sanitary landfills and inferred trenches that are predominantly located in the western portion of RMA. These sites contain trash and rubbish, but are not anticipated to contain drums of hazardous material, agent, or UXO.

Table 3.1-1 Summary of Medium Groups and Subgroups

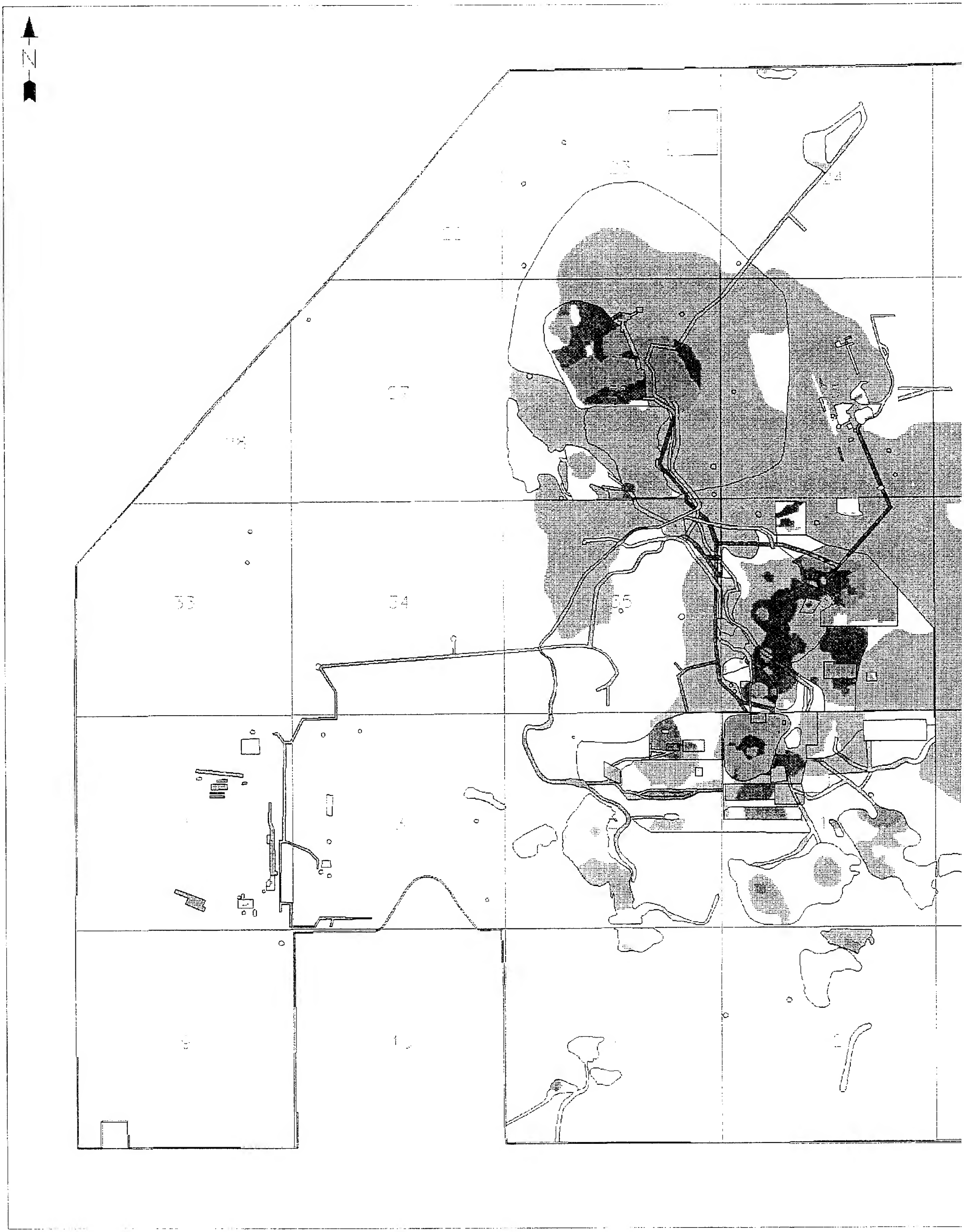
Medium Group	Subgroup	Sites	Description
Lime Basins	Section 36 Lime Basins	NCSA-1b	The Section 36 Lime Basins were used for the neutralization of process wastes related to agent production, and are characterized by soil/sludge mixtures with high pH levels and the potential presence of agent. COCs in the soil/sludge exceeding the Human Health SEC include primarily OCPs. This subgroup is distinguished by the higher percentages of OCPs. IRA activities at this site have consisted of the placement of a soil cap across the entire site.
	Buried M-1 Pits	SPSA-1e	The Buried M-1 Pits were used for the neutralization of process wastes related to agent production, and are characterized by soil/sludge mixtures with high pH levels and the potential presence of agent. COCs in the soil/sludge exceeding the Human Health SEC primarily consist of arsenic and mercury. This subgroup is distinguished by the higher percentages of volatiles and arsenic exceedance volumes.
South Plants	South Plants Central Processing Area	SPSA-1a	This subgroup consists of the main processing area within South Plants. Contamination has resulted from chemical disposal, storage, manufacturing, and agent demilitarization. A wide range of COCs in the soil exceeding the Human Health SEC include volatiles, OCPs, and arsenic. COCs exceeding the Biota SEC include aldrin, dieldrin, arsenic, and mercury.
	South Plants Ditches	SPSA-1d SPSA-2d SPSA-3a SPSA-4a SPSA-5a SPSA-8b SPSA-9a	This subgroup consists of the drainage ditches within South Plants. Contamination has resulted from chemical disposal, storage, manufacturing, and agent demilitarization. COCs in the soil exceeding the Human Health SEC include primarily OCPs.
	South Plants Tank Farm	SPSA-2a SPSA-2b	This subgroup consists of the tank farm area within South Plants where contamination has resulted from chemical storage. COCs in the soil exceeding the Biota SEC include aldrin and OCPs. This subgroup is further characterized by the potential for indirect exposure from DCPD vapors that have been discovered in the tank area.

Table 3.1-1 Summary of Medium Groups and Subgroups

Medium Group	Subgroup	Sites	Description
	South Plants Balance of Areas	SPSA-1b SPSA-1c SPSA-1g SPSA-2c SPSA-2e SPSA-3b SPSA-3c SPSA-3d SPSA-3e SPSA-4b SPSA-5b SPSA-7b SPSA-7c SPSA-8a SPSA-9b SPSA-12a SPSA-12b	The remainder of the sites within South Plants have been placed in this subgroup. Contamination at these sites has resulted from chemical disposal, storage, and manufacturing and agent demilitarization. COCs in the soil exceeding the Human Health SEC primarily consist of OCPs and ICP metals. This subgroup is also characterized by the potential presence of HE-filled UXO.
Buried Sediments/ Ditches	Buried Sediments	SSA-3a SSA-3b	This subgroup consists of two sites that are related to buried lake sediments. These sites contain contaminated sediments that were dredged from the adjacent lakes (Lake Ladora and Derby Lake), deposited in unlined ditches at their current locations, and covered with clean soil. COCs exceeding the Human Health SEC include OCPs.
	Sand Creek Lateral	NCSA-5b NCSA-5c NPSA-4 SSA-2b WSA-6a	This subgroup consists of the northern and southern segments of the Sand Creek Lateral that transported runoff from the South Plants Central Processing Area during storm events and snowmelt and drainage ditches used to transport water to and from the Secondary Basins and to drain the South Plants and North Plants process areas. COCs in the soil exceeding the Human Health SEC primarily consist of OCPs.

Table 3.1-1 Summary of Medium Groups and Subgroups

Medium Group	Subgroup	Sites	Description
Undifferentiated	Section 36 Balance of Areas	CSA-1b CSA-2a CSA-4	Sites within this subgroup are located in the southeastern area of Section 36 in the Central Study Area. They do not have unique site type characteristics or contamination patterns. COCs in the soil exceeding the Human Health SEC include OCPs and CLC2A. This subgroup is also characterized by the potential presence of agent-filled UXO.
	Burial Trenches	ESA-2a ESA-2c	Sites within this subgroup consist of trenches that are located in Sections 30 and 32 in the Eastern Study Area. They do not have unique site type characteristics or contamination patterns. COCs in the soil exceeding the Human Health SEC include chromium and lead. The sites are also characterized by the potential presence of HE-filled UXO.



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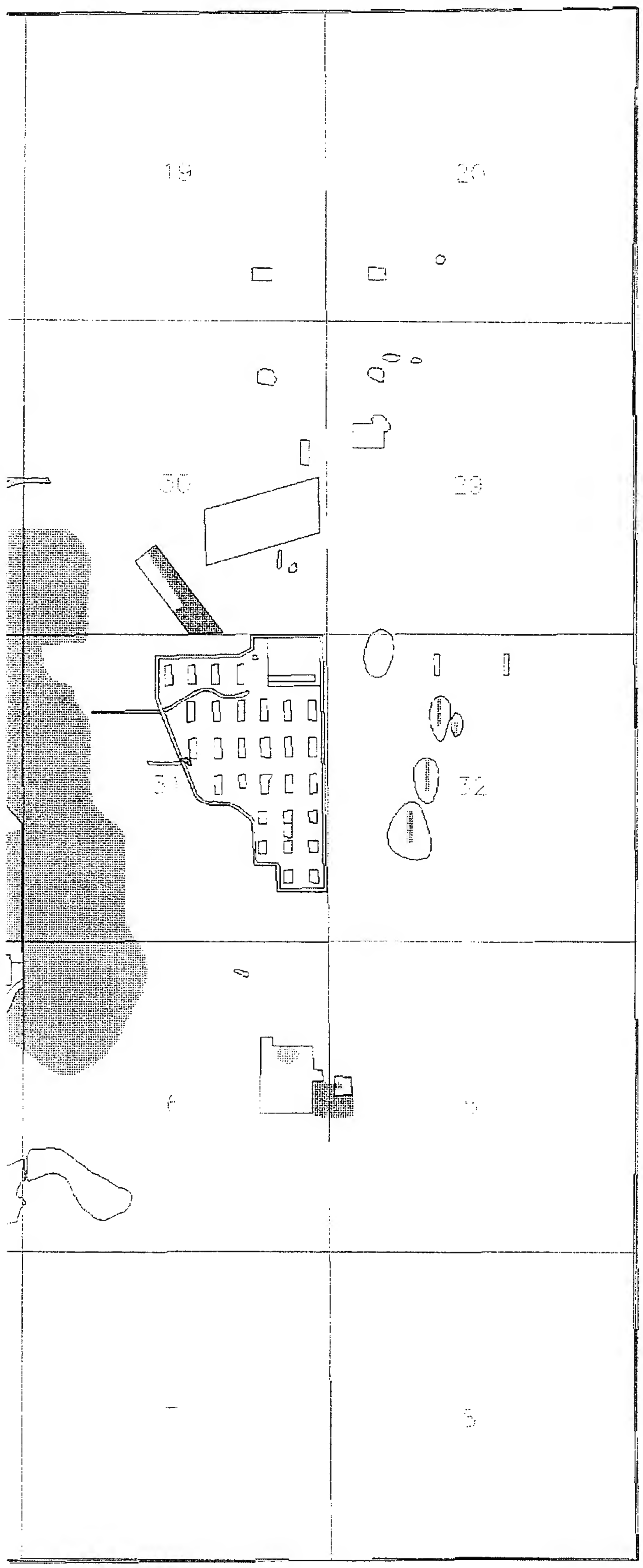


Legend

Arsenal Boundary

Principal Threat (1000X PRGs) Exceedance Area

Human Health Site Evaluation Criteria Exceedance Area

Biota (HI > 10) Exceedance Area

SARsite Boundary

Section Number

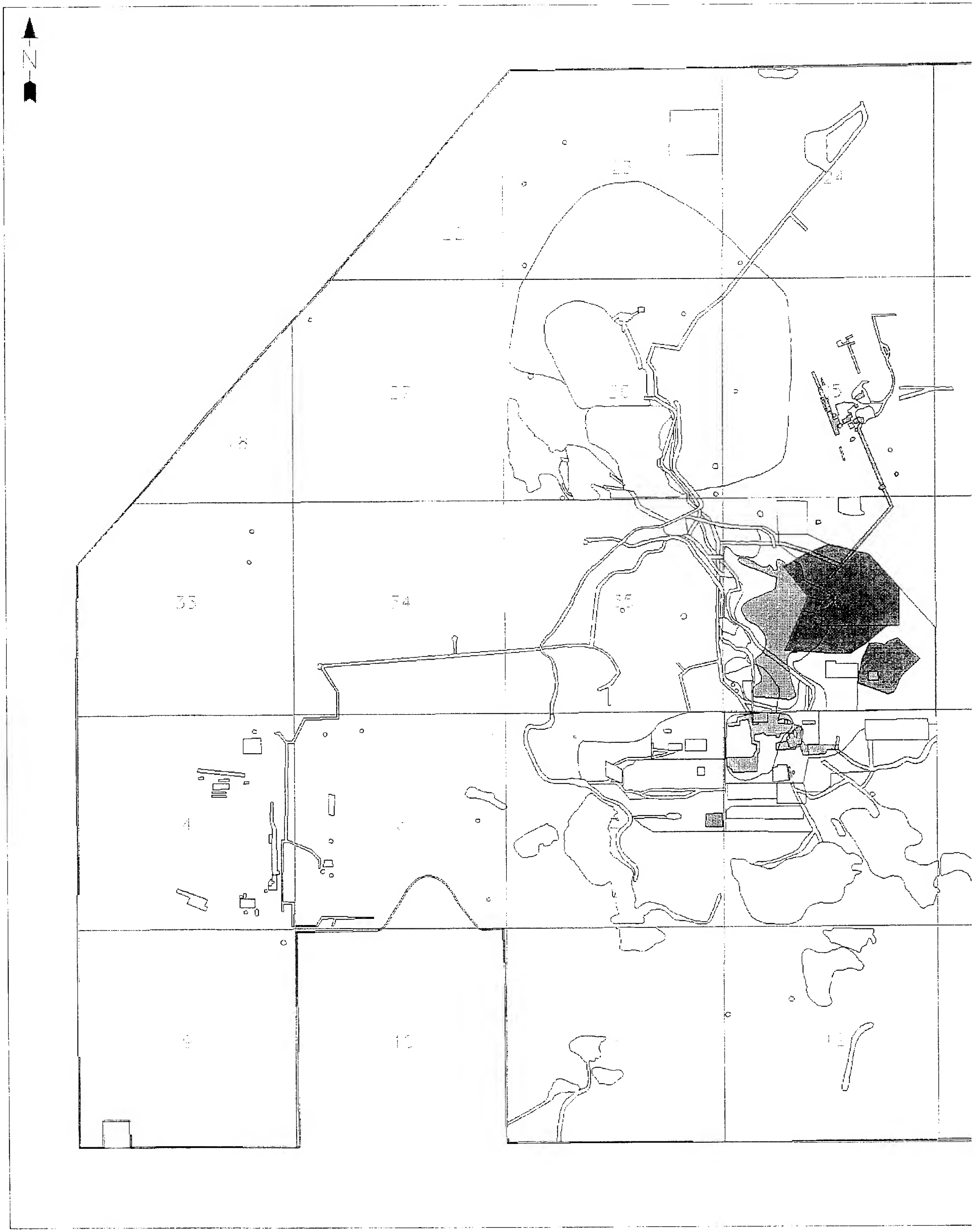
1500 0 1500 3000 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 3.1-1

Human Health/Biota Exceedance Areas

Ebasco Services Incorporated
July 1993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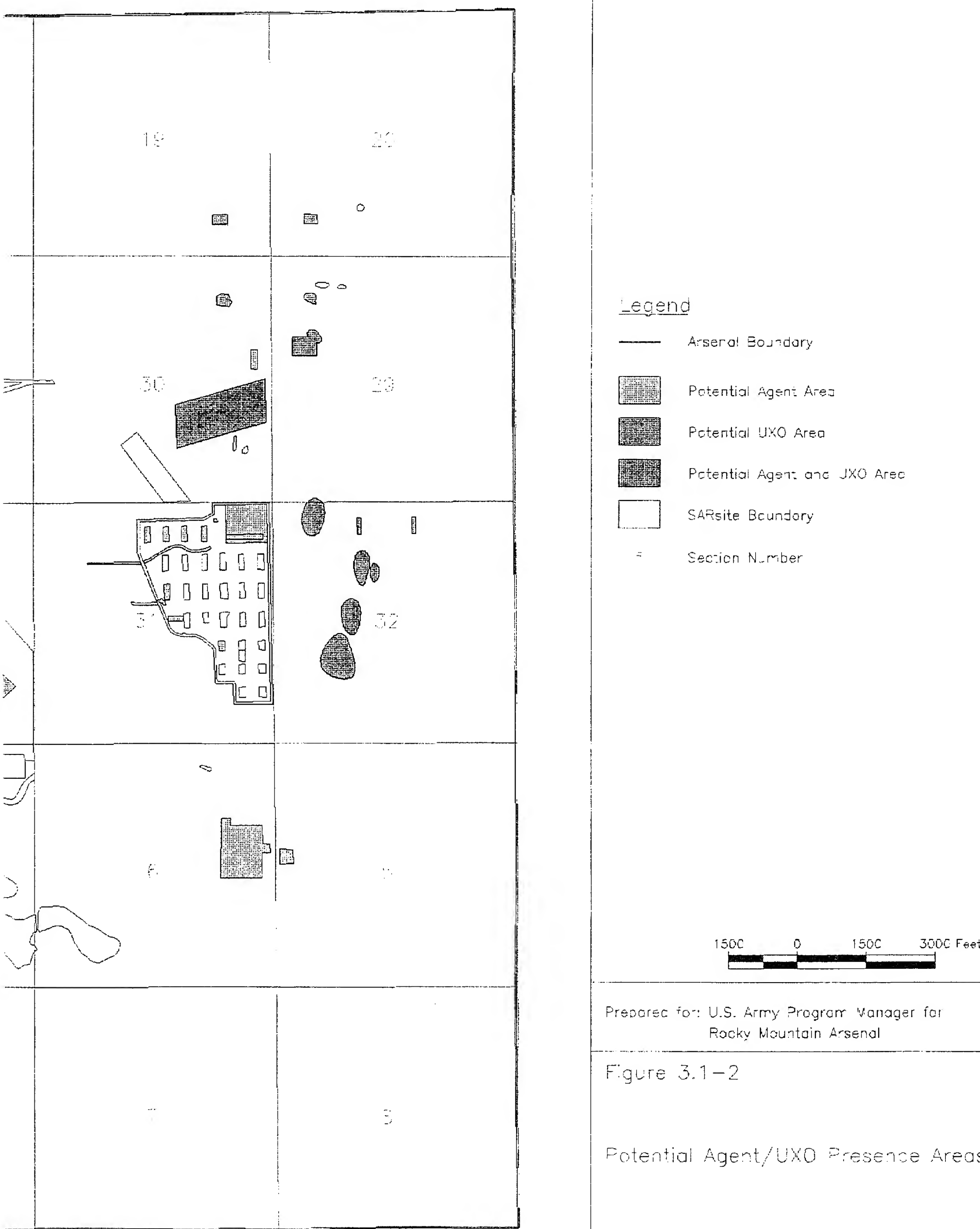


Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 3.1-2

Potential Agent/UXO Presence Areas

Ebasco Services Incorporated
July 1993

Figure 3.2-1 Alternatives Screening Summary for Munitions Testing Medium Group, Potential UXO Presence Exceedance Category

ALTERNATIVES DEVELOPED		ALTERNATIVES RETAINED	
No Action and Institutional Controls Alternatives			
U1.	No Additional Action (Provisions of FFA)	U1.	No Additional Action (Provisions of FFA)
Containment Alternatives			
U2.	Caps/Covers (Soil Cover)	U2.	Caps/Covers (Soil Cover)
Treatment Alternatives			
U3.	Incineration/Pyrolysis (Rotary Kiln)	U3.	Incineration/Pyrolysis (Rotary Kiln)
U4.	Incineration/Pyrolysis (Off-Post Incineration)	U4.	Incineration/Pyrolysis (Off-Post Incineration)

Figure 3.2-2 Alternatives Screening Summary for Agent Storage Medium Group, Potential Agent Presence Category

ALTERNATIVES DEVELOPED		ALTERNATIVES RETAINED	
No Action and Institutional Controls Alternatives			
A1.	No Additional Action (Provisions of FFA)	A1.	No Additional Action (Provisions of FFA)
Containment Alternatives			
A2.	Caps/Covers (Soil Cover)	A2.	Caps/Covers (Soil Cover)
Treatment Alternatives			
A3.	Direct Soil Washing (Solution Washing); Landfill (On-Post Landfill)	A3.	Direct Soil Washing (Solution Washing); Landfill (On-Post Landfill)
A4.	Incineration/Pyrolysis (Rotary Kiln)	A4.	Incineration/Pyrolysis (Rotary Kiln)

Figure 3.2-3 Alternatives Screening Summary for Lake Sediments Medium Group, Biota Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
B1. No Additional Action (Provisions of FFA)	B1. No Additional Action (Provisions of FFA)
Containment Alternatives	
B3. Landfill (On-Post Landfill)	B3. Landfill (On-Post Landfill)
B4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
Treatment Alternatives	
B6. Direct Thermal Desorption (Direct Heating)	B6. Direct Thermal Desorption (Direct Heating)
B7. Incineration/Pyrolysis (Rotary Kiln)	
B8. Incineration/Pyrolysis (Off-Post Incineration)	
B10. In Situ Biological Treatment (Aerobic Biodegradation)	B10. In Situ Biological Treatment (Aerobic Biodegradation)

Figure 3.2-4 Alternatives Screening Summary for Surficial Soils Medium Group, Biota Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
B1. No Additional Action (Provisions of FFA)	B1. No Additional Action (Provisions of the FFA)
Containment Alternatives	
B3. Landfill (On-Post Landfill)	B3. Landfill (On-Post Landfill)
B4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
Treatment Alternatives	
B6. Direct Thermal Desorption (Direct Heating)	
B7. Incineration/Pyrolysis (Rotary Kiln)	
B8. Incineration/Pyrolysis (Off-Post Incineration)	
B9. In Situ Biological Treatment (Landfarm/Agricultural Practice)	B9. In Situ Biological Treatment (Landfarm/Agricultural Practice)
B11. In Situ Thermal Treatment (Surface Soil Heating)	B11. In Situ Thermal Treatment (Surface Soil Heating)

Figure 3.2-5 Alternatives Screening Summary for Ditches/Drainage Areas Medium Group, Biota Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
B1. No Additional Action (Provisions of FFA)	B1. No Additional Action (Provisions of the FFA)
B2. Biota Management (Exclusion)	B2. Biota Management (Exclusion)
Containment Alternatives	
B3. Landfill (On-Post Landfill)	B3. Landfill (On-Post Landfill)
B4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
B5. Caps/Covers (Clay/Soil Cap)	B5. Caps/Covers (Clay/Soil Cap)
Treatment Alternatives	
B6. Direct Thermal Desorption (Direct Heating)	B6. Direct Thermal Desorption (Direct Heating)
B7. Incineration/Pyrolysis (Rotary Kiln)	
B8. Incineration/Pyrolysis (Off-Post Incineration)	
B9. In Situ Biological Treatment (Landfarm/Agricultural Practice)	B9. In Situ Biological Treatment (Landfarm/Agricultural Practice)
B11. In Situ Thermal Treatment (RF/Microwave Heating)	B11. In Situ Thermal Treatment (RF/Microwave Heating)

Figure 3.2-6 Alternatives Screening Summary for Basin A Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment[1]
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[2]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
17. In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)	17. In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	

[1] Alternative 9, Direct Soil Washing (Solution Washing); Direct Thermal Treatment retained pending favorable treatability study results.

[2] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-7 Alternatives Screening Summary for Basin F Wastepile Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
6. Cap/Covers (Clay/Soil Cap)	
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment[1]
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[2]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	

1 Alternative 9, Direct Soil Washing (Solution Washing); Direct Thermal Treatment retained pending favorable treatability study results.

2 Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-8 Alternatives Screening Summary for Secondary Basins Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment[1]
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[2]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
17. In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)	17. In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	

[1] Alternative 9, Direct Soil Washing (Solution Washing); Direct Thermal Treatment retained pending favorable treatability study results.

[2] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-9 Alternatives Screening Summary for Sewer Systems Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[1]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-10 Alternatives Screening Summary for Disposal Trenches Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
13. Direct Thermal Desorption (Direct Heating)	
14. Incineration/Pyrolysis (Rotary Kiln)	14. Incineration/Pyrolysis (Rotary Kiln)
15. Incineration/Pyrolysis (Off-Post Incineration)	

Figure 3.2-11 Alternatives Screening Summary for Sanitary Landfills Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[1]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-12 Alternatives Screening Summary for Lime Basins Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
10. Direct Solidification/Stabilization (Proprietary Agent Solidification)	10. Direct Solidification/Stabilization (Proprietary Agent Solidification)
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)[1]	
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
21. In Situ Thermal Treatment (Vitrification)	21. In Situ Thermal Treatment (Vitrification)

[1] Alternative 10, Direct Solidification/Stabilization (Proprietary Agent Solidification) retained pending favorable treatability study results for immobilizing organics and inorganics.

[2] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-13 Alternatives Screening Summary for South Plants Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Additional Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[1]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
16. In Situ Physical/Chemical Treatment (Vacuum Extraction); In Situ Solidification/Stabilization (Proprietary Agent Solidification)	16. In Situ Physical/Chemical Treatment (Vacuum Extraction); In Situ Solidification/Stabilization (Proprietary Agent Solidification)
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-14 Alternatives Screening Summary for Buried Sediment/Ditches Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
6. Cap/Covers (Clay/Soil Cap)	6. Cap/Covers (Clay/Soil Cap)
Treatment Alternatives	
7. Direct Physical/Chemical Treatment (Dechlorination)	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
10. Direct Solidification/Stabilization (Proprietary Agent Solidification)	10. Direct Solidification/Stabilization (Proprietary Agent Solidification)
11. Direct Biological Treatment (Aerobic Bioreactor)	
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[1]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-15 Alternatives Screening Summary for Undifferentiated Medium Group, Human Health Exceedance Category

No Action/Institutional Controls Alternatives

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)

Containment Alternatives

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)

Treatment Alternatives

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
10. Direct Solidification/Stabilization (Proprietary Agent Solidification)	10. Direct Solidification/Stabilization (Proprietary Agent Solidification)[1]
11. Direct Biological Treatment (Aerobic Bioreactor)	
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[2]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

4.0 DETAILING OF ALTERNATIVES

This section provides an overview of alternatives evaluated in the Soils DAA. The majority of the alternatives evaluated for the Soils DAA were those retained from the Soils DSA, although a few additional alternatives are considered in the Soils DAA and several retained alternatives are modified. Table 4.0-1 presents the alternatives evaluated for the Potential UXO Presence and Potential Agent Presence Categories and the Biota Exceedance and Human Health Exceedance Categories. Section 4.1 discusses assumptions used in detailing alternatives. Section 4.2 presents a brief discussion of how the retained alternatives in the DSA are modified for the DAA. The Technology Description Volume provides a detailed description of the technologies and process options used in the retained remedial alternatives. Finally, Sections 4.3 through 4.6 present a description of the alternatives evaluated in the DAA for each of the exceedance categories.

4.1 BASIS OF ALTERNATIVE DETAILING

The following section discusses several assumptions regarding the detailing of alternatives including monitoring, availability of borrow soils and centralized treatment/disposal facilities. It was assumed for the purposes of the FS that ambient air monitoring during excavation and any required surface water monitoring is included under the CMP. As a result, air and surface water monitoring is not included in the detailing of soils alternatives. In addition, an extensive ongoing groundwater monitoring program is already in place at RMA under the CMP. Therefore, groundwater monitoring wells are generally not addressed separately for alternatives that require groundwater monitoring to observe potential migration of contaminants or the effectiveness of the alternative.

The alternatives described in the following sections specify the use of common soils for backfill and in soil/vegetation layers of caps/covers and the use of low-permeability soils for caps/covers and liners. The ongoing FS soil Support Study is performing geotechnical studies to identify potential borrow areas for both common soil and low-permeability soil materials. The detailing of alternatives assumes that common soils are readily available based on the wide range of

suitable soils at RMA, but that low-permeability soils are only available in the northeast portion of RMA based on the higher clay content in soils at that location.

As discussed in Section 3.1, the detailing of alternatives considers centralized treatment and containment facilities. The sizing of these facilities is based on the largest volume of soils that might be sent to the facility. Following the selection of preferred alternatives, the usage of centralized facilities and their sizing will be reviewed and the alternative costs revised. Section 20 summarizes the selection of preferred alternatives and addresses these adjustments.

4.2 OVERVIEW OF ALTERNATIVE MODIFICATIONS

The alternatives retained in the Soils DSA were selected from the following general response action categories: No Action/Institutional Controls, Containment, and Treatment. As discussed in Section 1.4, the Soils DAA also developed alternatives that address principal threat volumes through treatment and the balance of each site through engineering or institutional controls. However, containment alternatives are still considered for principal threat volumes. This has resulted in the creation of several new alternatives and the modification of a number of alternatives (Section 4.2.1). A number of alternatives were also modified to account for consolidating soils with low levels of contamination into nearby areas for containment to minimize the areas requiring long-term maintenance and to maximize unrestricted habitat area. Section 4.2.2 presents an overview of the changes relative to consolidation, and Section 4.2.3 summarizes the changes in alternatives relative to determining treatment is only required for organic contaminants (and not inorganics). Two additional alternatives (U3a and U3b) were added in the Soils DAA to address the different procedures for treating HE-filled and agent-filled UXO.

4.2.1 Principal Threat Alternatives

As discussed in Section 1.4.3, principal threat volumes were estimated based on an excess cancer risk of 10^{-3} and an HI of 1,000. Existing alternatives retained in the DSA were modified to address these volumes. For the human health No Additional Action alternatives, two additional

alternatives were considered to address treatment of principal threats. Under Alternatives 1a and 1b, the principal threat volume is excavated, transported, and treated by thermal desorption (Alternative 1a, for principal threats that consist only of organics) or thermal desorption followed by solidification (Alternative 1b, for principal threats that consist of organic and inorganic contaminants). The treated principal threat volumes are then returned to the site as backfill.

The entire contaminated soil volumes for the Basin F Wastepile Medium Group and the Buried M-1 Pits, Complex Trenches, Hex Pit, and Shell Trenches Subgroups are designated as principal threat volumes. Therefore, alternatives consisting of combinations of treatment and containment are not evaluated for these sites. The Basin F Exterior and Section 36 Lime Basins both contain exceedances of the principal threat criteria. Alternatives consisting of combinations of treatment and containment were not considered for these two subgroups based on concerns regarding the ability to identify and excavate isolated soil volumes with principal threat exceedances.

Institutional controls and containment alternatives (Alternative 2: Access Restrictions [Modifications to FFA], Alternative 3: Landfill [On-Post Landfill], and Alternative 6: Caps/Covers [Clay/Soil Cap]) were modified to include treatment of principal threat volumes for the Former Basin F, Chemical Sewers, South Plants Ditches, and South Plants Balance of Areas Subgroups. For these alternatives, the principal threat volume is excavated, transported, and treated by thermal desorption and then returned to the site as backfill. Upon treatment of the principal threat volume, the containment or institutional controls portion of the alternative is implemented for the balance of the area. The modified alternatives are as follows:

- Alternative 2a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modifications to FFA)

- Alternative 3a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill)

- Alternative 6b: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Consolidation

- Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Modifications to Existing System

- Alternative 6f: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap)

For the South Plants Central Processing Area Subgroup, the principal threat volume includes both organic and inorganic contaminants, and direct thermal desorption and solidification were incorporated into Alternative 6: Caps/Covers (Clay/Soil Cap) to form Alternative 6a: Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap). The principal threat volumes are excavated, transported, treated/immobilized, and returned to the site as backfill. Upon treatment/immobilization of the principal threat volume, the containment portion of the alternative is then implemented for the balance of the soils in the subgroup.

4.2.2 <u>Incorporation of Consolidation Alternatives</u>

In the DAA, two containment alternatives—Alternative 6: Caps/Covers (Clay/Soil Cap) and Alternative 5: Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Walls)—were modified to include consolidation of contaminated soil at designated areas for containment by a clay/soil cap. As discussed in Section 3.1, consolidation of contaminated soils is considered for several reasons including minimizing areas at RMA requiring long-term maintenance, reducing cap and revegetation maintenance costs, and minimizing habitat restrictions. The excavated areas are backfilled with borrow material and revegetated with native grasses in accordance with a refuge management plan. The modified containment alternatives are as follows:

- Alternative 6b: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Consolidation

- Alternative 6g: Caps/Covers (Clay/Soil Cap) with Consolidation

For the Basin F Exterior, Buried Sediments/Ditches, Sand Creek Lateral, Secondary Basins, and Section 36 Balance of Areas Subgroups, Alternative 6 (which does not include consolidation) was

evaluated in addition to the modified alternative, Alternative 6g, which does include consolidation. For the South Plants Ditches and South Plants Balance of Areas, Alternative 6 as well as the modified Alternative 6b (which includes treatment of the principal threat area) were evaluated.

Containment alternatives for the Sanitary Landfills Medium Group and Complex Trenches Subgroup do not incorporate consolidation at a nearby site. For these areas, contaminated soil outside disposal landfills and trenches is excavated and used as grading fill prior to containment by capping. By consolidating areas outside the disposal trenches and landfills, the area requiring capping can be significantly reduced.

For the Ditches/Drainage Areas Medium Group, Alternative B5: Caps/Covers (Clay/Soil Cap) was replaced with Alternative B5a: Caps/Covers (Clay/Soil Cap) with Consolidation. Contaminated soils from the Ditches/Drainage Areas Medium Group are excavated and consolidated in Basin A prior to containment by capping. The site is then returned to grade using borrow material and revegetated to restore habitat. Alternatives for the biota exceedance portion of several Human Health Exceedance Category subgroups also include consolidation.

4.2.3 Treatment Alternatives

Some of the treatment alternatives retained in the DSA (Alternatives 9, 13, 16, and 19) were modified in the DAA to address treatment of soil exceedance volumes that contain organic contaminants only. By refining contaminated soil volumes and characteristics of subgroups during the DAA, many subgroups were identified that contain organic exceedances only. For these subgroups, solidification of inorganics is not required and is deleted. Solidification is retained, however, for the Basin A Medium Group and the Buried M-1 Pits, South Plants Central Processing, South Plants Balance of Areas, and Burial Trenches Subgroups, which do contain inorganic exceedances. The modified alternatives are as follows:

- Alternative 9a: Direct Soil Washing (Solution Washing); Direct Thermal Desorption (Direct Heating)

- Alternative 13a: Direct Thermal Desorption (Direct Heating)
- Alternative 16a: In Situ Physical/Chemical Treatment (Vacuum Extraction)
- Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating)

4.3 ALTERNATIVES FOR THE POTENTIAL UXO PRESENCE CATEGORY

Four alternatives were retained for the Potential UXO Presence Category, including no additional action, containment, and on-post and off-post demilitarization of UXO. The Munitions Testing Medium Group is the only medium group within this exceedance category. The alternatives developed for this medium group in the DSA were modified for the DAA by the addition of two modified alternatives and are briefly described in the following sections. The alternatives for addressing UXO consider Department of Defense (DOD) regulations governing the demilitarization of munitions. Excavated UXO filled with high explosives (HE) are to be transported to a demolition site or detonated on site if the munition is considered unsafe for transport (DARCOM-R 385-100). If the excavated UXO contains Army agent, the munitions are either incinerated in a specially designed incinerator after the fuses are removed, or are packaged and transported to an off-post Army facility for demilitarization. The two modified alternatives, Alternative U3a and Alternative U4a, account for these different procedures used to treat HE-filled and agent-filled UXO. The six alternatives for this category are also evaluated as part of the overall remedial alternatives for Human Health Exceedance Category subgroups that potentially contain UXO. The modified alternatives are as follows:

Alternative U3a: Detonation (On-Post Detonation)
Alternative U4a: Detonation (Off-Post Facility)

In addition to the Munitions Testing Medium Group, UXO may be found at other RMA sites in the Basin A, Disposal Trenches, South Plants, and Undifferentiated Medium Groups. However, the areas with potential UXO presence in these medium groups generally overlap with human health and/or biota exceedances, and UXO is dealt with as part of the human health or biota alternatives for these medium groups. The Munitions Testing Medium Group, South Plants

Balance of Areas Subgroup, and Burial Trenches Subgroup contain potential UXO presence areas where HE-filled UXO were tested or detonated. As such, these areas are evaluated for the potential presence of HE-filled munitions. The remaining areas with the potential presence of UXO are evaluated as agent-filled UXO.

4.3.1 Alternative U1: No Additional Action (Provisions of FFA)

Alternative U1 is a no action/institutional controls alternative. Under this alternative, no specific actions are taken to address the physical hazards associated with potential UXO. The major components of Alternative U1 are the following:

- No further action beyond the FFA restrictions
- Monitoring through site reviews to observe site conditions

The provisions of the FFA (EPA et al. 1989/RIC 89068R01) promote protection of human health by prohibiting residential development, the consumption of all game and fish taken at RMA, and the conduct of agricultural activities other than erosion control or related remedial activities. No IRAs currently exist at UXO sites within the Munitions Testing Medium Group, although the Army continues to investigate new technologies for identifying subsurface UXO. Under the No Action alternative, site conditions are monitored as part of the 5-year site review procedure, although no additional soil sampling is conducted.

4.3.2 Alternative U2: Caps/Covers (Soil Cover)

Alternative U2 is a containment alternative that reduces physical hazards associated with UXO by interrupting exposure pathways. The major components of Alternative U2 are the following:

- Surface sweep and geophysical clearance of surface soils
- Containment of areas potentially containing UXO by installing a 4-ft-thick soil cover that prevents exposure but is not intended to provide a barrier to infiltration
- Monitoring through site reviews and maintenance operations to determine effectiveness of containment systems

The 4-ft-thick soil cover consists of 3-1/2 feet of clean, noncohesive borrow material to provide a uniform cover and 6 inches of topsoil to support the development of vegetation (Section 6.1 of the Technology Description Volume). The cover is slightly convex, with an upper slope of between 1.5 and 3 percent to reduce infiltration and erosion of the cover. The native perennial grasses used to cover the top layer are capable of surviving at a sufficient density to minimize erosion of the cover with little or no maintenance. The grasses impede erosion, but also allow surface runoff from major storm events.

Prior to placing the soil cover, surface sweeps and geophysical surveys are conducted to ensure the safety of heavy equipment and personnel working above potential UXO in near-surface soils. The surface sweep is conducted to ensure all areas of the site have been inspected for UXO at the surface. Following the surface sweep, a magnetometer survey is conducted to identify any near-surface UXO or debris. If UXO is identified during the survey, clearance procedures are followed as described in Section 4.3.3.

Following the installation of the cover, site controls are implemented to maintain the integrity of the cover and to ensure that the cover limits potential physical hazards to humans and biota from soils containing UXO. Access controls ensure that the cover is not disturbed or excavated. Any burrowing animals are relocated away from the site to ensure the integrity of the cover and the protection of burrowing animals from physical hazards below the cover. Maintenance activities ensure the repair of any erosion damage, and the integrity of the cover is evaluated as part of the 5-year review.

4.3.3 Alternative U3: Detonation (On-Post Detonation); Incineration/Pyrolysis (Rotary Kiln/Incineration)

Alternative U3 is a treatment alternative that demilitarizes UXO on post. The major components of Alternative U3 are the following:

- Geophysical clearance of sites to identify UXO prior to excavation

- Excavation of soils with UXO, separation of UXO from excavated material, and identification of UXO as being filled with agent or high explosives

- Removal of fuses from agent-filled UXO and treatment of agent-filled casing using on-post rotary kiln incineration and detonation of HE-filled UXO and fuses removed from agent-filled UXO

- Excavation of surface debris and associated soils and disposal in the on-post landfill as discussed in Section 4.6.6

A magnetometer survey is used to identify the locations of UXO prior to excavation. The removal of UXO consists of scraping overlying soil and debris in areas of geophysical anomalies using earth-moving equipment such as backhoes or bulldozers. Conventional excavation equipment can be adapted with safety shields or other specialized equipment to guard against explosions during removal operations. If the geophysical anomaly consists of UXO, the UXO and surrounding soil are excavated from the site, and the UXO is separated and packaged for on-post transportation.

The surficial soils and debris excavated during the removal of UXO are placed in the centralized on-post landfill (Section 4.6.6). During UXO removal operations, dust emissions are suppressed as described in Section 4.1 of the Technology Description Volume. Equipment operators are to be highly trained in explosive ordnance identification and are required to wear appropriate protective clothing. Excavation procedures are developed to avoid accidental detonation of UXO. To avoid erosion at the disturbed area, runoff control measures are applied as necessary, and the site is backfilled and regraded. A 6-inch layer of topsoil is placed over the disturbed area and revegetated with native grasses in accordance with a refuge management plan.

Agent-filled UXO is inspected following excavation to identify those that pose an immediate hazard and that cannot be safely transported. Such UXO requires emergency disposal action, which consists of detonating the UXO in place or rendering the UXO a nonimminent hazard. UXO that does not pose an immediate hazard is transported to the on-post rotary kiln incinerator for demilitarization. The fuses and explosive components of agent-filled UXO are removed and

detonated. The remaining casing is then drained of all agent and the empty casing is processed through a rotary kiln incinerator at 1,000 degrees Fahrenheit (°F) for 15 minutes to destroy any remaining agent in accordance with Army regulations (AMC-R 385-131). The agent is stored in a storage tank from which it is later injected into the secondary chamber of the rotary kiln using a liquid nozzle. The secondary combustion chamber operates at a temperature of 2,250°F, which is above the 1,000°F minimum (AMC-R 385-131) required for 5X decontamination. Section 9.1 of the Technology Description Volume provides a description of the rotary kiln incineration of UXO, including the off-gas system.

The Technology Description Volume presents the criteria for siting the detonation areas for HE-filled UXO. Site ESA-4b was historically used for detonation of munitions (Site 290-4) (ESE 1988/RIC 88103R04) and is considered adequate for detonation of fuses and explosive components.

4.3.4 Alternative U3a: Detonation (On-Post Detonation)

Alternative U3a is a treatment alternative that demilitarizes UXO on post. This alternative was developed for areas which include HE-filled UXO only. The major components of Alternative U3a are the following:

- Geophysical clearance of sites to identify UXO prior to excavation
- Excavation of soils with HE-filled UXO, separation of UXO form excavated material
- Detonation of HE-filled UXO in the designated detonation area
- Excavation of surface debris and associated soils and disposal in the on-post landfill as discussed in Section 4.6.6

A magnetometer survey is used to identify the locations of UXO prior to excavation. Excavation and UXO removal are conducted as described in Section 4.3.3. HE-filled UXO is then hauled to the detonation area, Site ESA-4b, as described in Section 4.3.3. To prevent erosion of the disturbed area, runoff control measures are applied as necessary, and the site is backfilled and

regraded. A 6-inch layer of topsoil is placed over the disturbed area and revegetated in accordance with a refuge management plan.

4.3.5 Alternative U4: Detonation (Off-Post Facility); Incineration/Pyrolysis (Off-Post Incineration)

Alternative U4 is a treatment alternative for UXO that involves transport of UXO to an off-post facility for demilitarization. The major components of this alternative are the following:

- Geophysical clearance of sites to identify UXO prior to excavation
- Excavation of soils with UXO and packaging and transport of the UXO by truck or rail to an existing Army facility
- Treatment of agent-filled UXO at an existing off-post Army incinerator and detonation of HE-filled UXO at an existing Army facility
- Excavation of surface soils and debris and disposal in the on-post landfill

As discussed in Section 4.3.3, a magnetometer is used to identify the locations of UXO prior to excavation. If the geophysical anomaly consists of UXO, the UXO and the surrounding soil are excavated from the site, and the UXO is separated and packaged for on-post transportation. UXO that cannot be safely transported are detonated in place. The surficial soils and debris excavated during the removal of UXO are placed in the centralized on-post landfill (Section 4.6.6). During excavation, runoff controls are implemented as necessary to prevent erosion. The disturbed area is backfilled, regraded, and covered with 6-inches of topsoil. The area is then revegetated in accordance with a refuge management plan. Specialized equipment to ensure the safety of personnel may be required to safely excavate the UXO. As with other UXO alternatives, only personnel trained in ordnance identification and handling are to be involved in remediation at sites with potential UXO presence.

Off-post demilitarization of UXO involves transportation of the UXO to an appropriate Army facility for demilitarization. UXO containing agent that are rendered safe for transport are shipped to an Army facility designed specifically for UXO demilitarization. The nearest

permitted Army incinerator specializing in agent-filled UXO demilitarization is at Tooele Army Depot near Tooele, Utah. HE-filled UXO are transported to Fort Carson Army Base in Colorado Springs, Colorado for detonation.

The Army's current chemical weapons disposal program, which includes Tooele Army Depot, involves robotics and machine disassembly of the chemical weapons as appropriate for each specific munition. The various waste materials from disassembly are incinerated separately as discussed in Section 9.2 of the Technology Description Volume. HE-filled UXO are detonated at Fort Carson Army Base in accordance with procedures outlined in DARCOM-R 385-100 for HE-filled UXO. Transportation requirements are outlined in AMC-R 385-131 for agent-filled UXO, in DARCOM-R 385-100 for HE-filled UXO, and by the Department of Transportation (DOT) for munitions transport in general. UXO incineration at Tooele Army Depot is completed to render the UXO nonhazardous, and all residual streams from the incineration process are controlled and managed by the off-post installation (i.e., Tooele Army Depot).

4.3.6 Alternative U4a: Detonation (Off-Post Army Facility)

Alternative U4a is a treatment alternative that demilitarizes UXO at an off-post facility. This alternative was developed for areas which include HE-filled UXO only. The major components of Alternative U4a are the following:

- Geophysical clearance of sites to identify HE-filled UXO prior to excavation
- Excavation of soils with HE-filled UXO and packaging and transport of the UXO by truck or rail to an existing Army facility
- Detonation of HE-filled UXO at the existing Army facility
- Excavation of surface soils and debris in the on-post landfill

A magnetometer survey is used to identify the locations of UXO prior to excavation. Excavation and UXO removal are conducted as described in Section 4.3.3. The HE-filled UXO are transported to Fort Carson Army Base in Colorado Springs, Colorado for detonation. Runoff

controls are implemented as necessary during excavation to minimize erosion. The excavated area is backfilled and regraded. A 6-inch topsoil layer is placed over the disturbed area and revegetated in accordance with a refuge management plan.

4.4 ALTERNATIVES FOR THE POTENTIAL AGENT PRESENCE CATEGORY

In the DSA, four alternatives were retained for the Potential Agent Presence Category. These alternatives include a no additional action alternative, a containment alternative and two treatment alternatives. Soil washing using solvent extraction, which had been rejected from further consideration in the DSA, was reintroduced for the DAA based on promising treatability study results. This exceedance category consists of a single medium group, the Agent Storage Medium Group, which is divided into the North Plants and Toxic Storage Yards Subgroups. These five alternatives are applicable to both subgroups. As with UXO, DOD regulations govern the treatment of soils containing agent (AMC-R 385-131).

In addition to sites within the Agent Storage Medium Group, agent may be found at other sites at RMA. These include areas within the Basin A, Sewer Systems, Disposal Trenches, Lime Basins, South Plants, and Undifferentiated Medium Groups. Appendix A describes the sites contained within these medium groups as well as the potential areas, depths, and volumes of agent-contaminated soils.

4.4.1 Alternative A1: No Additional Action (Provisions of FFA)

Alternative A1 is a no action/institutional controls alternative. No specific actions are undertaken to address acute chemical hazards associated with potential agent presence. The major components of Alternative A1 are the following:

- No further action beyond the FFA restrictions and the existing or planned IRAs
- Monitoring through site reviews to observe site conditions

The provisions of the FFA (EPA et al. 1989/RIC 89068R01) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and

agricultural activities other than erosion control or those related to remediation activities. No IRAs currently exist or are planned at sites within the Agent Storage Medium Group, although IRAs for structures in North Plants are planned. In addition, the ongoing Volume Refinement Program is attempting to identify agent-contaminated soils. Site conditions are monitored through 5-year site reviews, although no additional soil sampling is conducted.

4.4.2 Alternative A2: Caps/Covers (Soil Cover)

Alternative A2 is a containment alternative that reduces the acute hazards associated with agent-contaminated materials by interrupting exposure pathways. The major components of Alternative A2 are the following:

- Containment of soil potentially containing agent by installing a 4-ft-thick soil cover that prevents exposure but is not intended to provide a barrier to infiltration

- Monitoring through site reviews and maintenance operations to determine effectiveness of the containment systems

Section 4.3.2 discusses the installation of a soil cover under Alternative U2: Caps/Covers (Clay/Soil Cap). Four feet of soil are placed over the potential agent presence areas, including a 6-inch topsoil layer that is installed to facilitate revegetation of the cover. Section 4.3.2 also describes the long-term controls and maintenance requirements of the soil cover.

4.4.3 Alternative A3: Soil Washing (Solution Washing); Landfill (On-Post Landfill)

Alternative A3 is a chemical treatment alternative for agent-contaminated soils that achieves the 3X treatment level required by Army regulations (AMC-R 385-131). The major components of Alternative A3 are the following:

- Field screening of soil samples from borings to identify areas containing agent
- Excavation of soils with identified agent presence

- Treatment of agent in the excavated soils through direct soil washing with a caustic solution to neutralize agent compounds

- Treatment of aqueous effluent from solution washing by spray drying

- Disposal of the treated soils and the salts from spray drying in the on-post landfill as discussed in Section 4.6.6

Conventional excavation consists of removing soil and debris from its original location using common earth-moving equipment such as backhoes, bulldozers, front-end loaders, haul trucks, and scrapers. The most effective means of removing material from any given site is typically a combination of several types of equipment. Section 4.1 of the Technology Description Volume presents descriptions of the equipment used for excavating contaminated soils. For excavation in areas potentially contaminated with agent, real-time screening is performed prior to excavation to identify areas with agent presences as well as during excavation to ensure protection of site workers.

During excavation, dust emissions are suppressed as described in Section 4.1 of the Technology Description Volume. Equipment operators are required to wear appropriate protective clothing, and specific excavation procedures are applied to avoid the accidental release of agent. Runoff control measures are applied, as necessary, and the excavated area is backfilled, regraded, and revegetated with native grasses.

Caustic washing of agent-contaminated materials neutralizes the agent through alkaline hydrolysis. Neutralization may not necessarily destroy all agent present in the materials; therefore, it is classified as a 3X decontamination level of treatment. Figure 4.4-1 presents a schematic of the caustic washing of agent-contaminated soils. As discussed in Section 9.3 of the Technology Description Volume, an 18-percent sodium hydroxide (NaOH) solution is used to neutralize agent in soils. The soils are placed in a reactor and mixed with a NaOH solution at a ratio of 5:1 solution/soil. The resulting slurry is then mixed to ensure contact of the caustic solution with any agent present in the pore spaces of the soil. The solution is then removed from the reactor, and another three wash cycles are initiated, which results in a total residence time of 30 minutes. Since the Ph of an 18-percent NaOH solution is approximately 12, the pH of the treated materials approaches 12 following the four wash cycles. The treated materials are

neutralized to lower the pH, if required, and placed in the on-post landfill as described in Section 4.6.6. The equipment used for the caustic washing of soil is generally the same as that used for soil washing, which is described in Section 12 of the Technology Description Volume. However, the soil is not separated into coarse- and fine-grained soil fractions, and it uses a caustic wash.

The caustic solution used for washing is recycled for use in subsequent washings (with additional NaOH to bring it to full strength); however, a large volume of process water is generated. The process water, which consists of a brine, is evaporated by spray drying, and the salts are landfilled. Spray drying involves heating the brine with an infrared lamp to remove most of the water and then completing the drying in an oven at 110 degrees Centigrade (°C) (Section 9.3 of the Technology Description Volume).

4.4.4 Alternative A4: Incineration/Pyrolysis (Rotary Kiln Incineration)

Alternative A4 is a thermal treatment alternative for agent-contaminated soils that achieves the 5X decontamination level required by Army regulations (AMC-R 385-131). The major components of this alternative are the following:

- Field screening of soil samples from borings to identify areas containing agent
- Excavation of soils with identified agent presence
- Treatment of agent in excavated soils by rotary kiln incineration
- Removal and landfilling of particulates and salts with elevated levels of VOCs from the rotary kiln air pollution control equipment
- Backfilling of treated soils

The screening and excavation of soils with agent is discussed in Section 4.4.3 and described in Section 4.1 of the Technology Description Volume. The rotary kiln incineration system oxidizes or volatilizes all organic waste constituents in the soil matrix for subsequent combustion (oxidation) in the afterburner (Figure 4.4-2). To achieve a 5X level of decontamination, the rotary kiln is operated at a temperature of at least 1,000°F with a soils residence time of 15

minutes to ensure complete volatilization of all agent constituents (AMC-R 385-131). Off gas from the rotary kiln is fed to the afterburner for destruction of the VOCs. The afterburner operates at temperatures up to 2,250°F and must be able to withstand the high corrosivity of chlorides and iron compounds. Excess air is added to the afterburner to ensure destruction of 99.99 percent of the remaining organics present. The off-gas control system for a rotary kiln incinerator is described in Section 7.2 of the Technology Description Volume.

Approximately 10 percent of the solids feed are entrained as particulates in the off-gas stream; however, most particulates are recovered and combined with the treated soils. Approximately 1 percent of the total solids feed are recovered from the scrubber blowdown along with salts from the scrubber (Figure 4.4-2). These particulates and salts contain elevated levels of volatile inorganics, such as mercury and arsenic, which are volatilized during incineration. These residuals are placed in the on-post landfill.

The treated soils are backfilled on site, but the organic carbon content of the soils is destroyed during rotary kiln incineration. Therefore, topsoil is placed over the backfilled areas and revegetated with native grasses in accordance with a refuge management plan.

4.4.5 Alternative A5: Soil Washing (Solvent Washing); Landfill (On-Post Landfill)

Alternative A5 is a chemical treatment alternative for agent-contaminated soils that achieves the 3X treatment level required by Army regulations (AMC-R 385-131). The major components of Alternative A5, which was developed the DAA, are the following:

- Field Screening of soil samples during excavation to identify areas containing agent
- Excavation of soils with potential agent presence
- Screening and size reduction of the soils
- Separation of remaining oversize material and debris followed by disposal of oversized material in an on-post landfill

- Treatment of agent in the excavated soils through direct solvent washing, which utilizes a caustic organic solvent solution to adjust pH to a level that neutralizes agent compounds

- Treatment of organic effluent from solvent washing at an off-post treatment and disposal facility

- Disposal of treated soils in the on-post landfill as discussed in Section 4.6.6

Conventional excavation consists of removing soil and debris from its original location using common earth-moving equipment such as backhoes, bulldozers, front-end loaders, haul trucks, and scrapers. The most effective means of removing material from any given site is typically a combination of several types of equipment. Section 4.1 of the Technology Description Volume presents descriptions of the equipment used for excavating contaminated soils. For excavation in areas potentially contaminated with agent, real-time screening is performed prior to excavation to identify areas with agent presence as well as during excavation to ensure protection of site workers.

During excavation, dust emissions are suppressed as described in Section 4.1 of the Technology Description Volume. Equipment operators are required to wear appropriate protective clothing, and specific excavation procedures are applied to avoid the accidental release of agent. Runoff control measures are applied, as necessary, and the excavated area is backfilled, regraded, and revegetated with native grasses.

Solvent washing of agent-contaminated materials neutralizes the agent through alkaline hydrolysis. Neutralization may not necessarily destroy all agent present in the materials; therefore, it is classified as a 3X decontamination level of treatment. Figure 4.4-3 presents a schematic of the solvent/caustic washing of agent-contaminated soils. As discussed in Section 9.5 of the Technology Description Volume, the soils are screened for size, placed in a reactor, and mixed with a solvent and NaOH mixture. The resulting slurry is then mixed to ensure contact of the caustic solution with any agent present in the pore spaces of the soil. The solution is then removed from the reactor, and another two wash cycles are initiated, which

results in a total soils residence time of more than 30 minutes. Since the pH of the solvent washing system is approximately 12, the pH of the treated materials approaches 12 following the three wash cycles. The treated materials are neutralized to lower the pH, and placed in the on-post landfill as described in Section 4.6.6. The equipment used for the solvent/caustic washing of soil is generally the same as that used for solvent washing, which is described in Section 12 of the Technology Description Volume. However, the equipment has been modified to withstand the slightly higher pH anticipated in this system as compared to the standard solvent extraction system. The solvent is regenerated and the product organic solution is sent for off-post disposal.

4.5 ALTERNATIVES FOR THE BIOTA EXCEEDANCE CATEGORY

In the Soils DSA, eight alternatives were retained for the three medium groups (Lake Sediments, Surficial Soils, Ditches/Drainage Areas) in the Biota Exceedance Category. These alternatives include a no action alternative, a containment alternative, and both direct and in situ treatment alternatives, which are evaluated in Sections 6 through 10, for each of the three Biota Exceedance Category medium groups (Table 4.0-1). An additional alternative, Alternative B1a: Caps/Covers (Clay/Soil Cap with Consolidation; No Additional Action (Provisions of FFA), developed for the DAA and discussed in Section 4.5.2, consists of consolidating the highest levels of contamination from the inlets of the Lake Sediments Medium Group for containment in Basin A with no additional action for biota exceedances. Alternative B5: Caps/Covers (Clay/Soil Cap) was modified to include consolidation in Basin A as Alternative B5a: Caps/Covers (Clay/Soil Cap) with Consolidation. Alternative B10: In Situ Biological Treatment (Aerobic Biodegradation) was modified to include consolidation of contamination from the inlets of the lakes in a manner similar to Alternative B1a. In addition, several alternatives evaluated for the biota exceedance portions of Human Health Exceedance Category medium groups include slight deviations from the corresponding biota-only alternatives. Section 4.5.10 presents a brief discussion of the five alternatives considered for the biota exceedance portions of the Human Health Exceedance Category medium groups.

4.5.1 Alternative B1: No Additional Action (Provisions of FFA)

Alternative B1 is a no action alternative that was developed for all three of the medium groups in the Biota Exceedance Category. The major components of Alternative B1 are the following:

- No further action beyond FFA restrictions other than existing or planned IRAs
- Monitoring through annual soil sampling and site reviews to observe natural contaminant attenuation and potential contaminant migration

Land-use restrictions in the FFA (EPA et al. 1989/RIC 89068R01) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or those related to remediation activities. The time frame for natural attenuation to achieve Biota PRGs is estimated at more than 30 years based on the range of half-lives for the primary OCP contaminants presented in the RISR (EBASCO 1992a/RIC 92017R01). Contaminant levels are monitored on an annual basis to observe natural attenuation and potential contaminant migration, and 5-year site reviews are conducted. The No Additional Action alternative does not restrict habitat and vegetation modifications due to management of wildlife.

4.5.2 Alternative B1a: Caps/Covers (Clay/Soil Cap) with Consolidation, No Additional Action (Provisions of FFA)

Alternative B1a is a combined containment and no additional action alternative that was developed during the DAA for the Lake Sediments Medium Group. The major components of Alternative B1a are the following:

- Excavation of highest levels of contamination, which includes isolated human health exceedances, from inlets of lakes
- Consolidation of excavated sediments in Basin A as grading fill prior to installation of clay/soil cap
- No further action for remaining sediments beyond FFA restrictions other than existing or planned IRAs
- Monitoring of remaining sediments through annual sampling and site reviews to observe natural contaminant attenuation and potential contaminant migration

The inlets of the lakes are excavated using conventional earth-moving equipment such as backhoes. Section 4.1 of the Technology Description Volume contains a discussion of the techniques used to excavate wetlands, such as lake inlets, with a backhoe. The vegetation in these areas is cleared prior to excavation, and no dust controls are used due to the high moisture content of the excavated soils. A temporary cutoff wall is installed to prevent migration of suspended sediments into the lakes. The excavated areas are backfilled with topsoil, and the wetlands are restored.

The excavated soils are consolidated within Basin A as grading fill as discussed in Section 4.5.5. The installation of a clay/soil cap for Basin A requires between 1.2 and 1.8 million cubic yards (CY) of fill to achieve the design grades for capping (depending on the final grade desired). Although these soils exhibit the highest levels of OCPs in the lakes, the contaminant levels in the consolidated soils are lower than those in Basin A soils. This alternative is based on the selection of Alternative 6f for Basin A.

Land-use restrictions in the FFA (EPA et al. 1989/RIC 89068R01) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or those related to remediation activities. The time frame for natural attenuation to achieve Biota PRGs is estimated at more than 30 years based on the range of half-lives for the primary OCP contaminants presented in the RISR (EBASCO 1992a/RIC 92027R01). Contaminant levels in the remaining sediments are monitored on an annual basis to observe natural attenuation and potential contaminant migration, and 5-year site reviews are conducted to document any changes in the site characteristics.

4.5.3 Alternative B2: Biota Management (Exclusion, Habitat Modification)

Alternative B2 is a no action/institutional controls alternative that was developed for the Ditches/Drainage Areas Medium Group. The major components for Alternative B2 are the following:

- Exclusion of biota through fencing and habitat modification to reduce biota exposure to contaminated soils

- Monitoring through annual soil sampling and site reviews to observe natural contaminant attenuation and potential contaminant migration

The exclusion of biota from areas of contaminated soils is accomplished through physical barriers and changes to habitat quality. The installation of a 6-ft-high chain-link fence around an area of contaminated soils limits the entry of many mammals and therefore interrupts the exposure pathways. In addition, several types of vegetation are planted in the area to reduce the quality of the habitat and deter biota migration into a contaminated area. Section 3.1 of the Technology Description Volume discusses vegetation that could be used for habitat modification. The revegetation of a contaminated site with vegetation of poorer quality eliminates the use of the site as habitat.

Annual sampling of contaminated soils is used to detect potential contaminant migration and to observe natural attenuation/degradation of contaminants. The time frame for natural attenuation to achieve Biota PRGs is estimated to be more than 30 years based on the range of half-lives for the primary OCP contaminants presented in the final RISR (EBASCO 1992a/RIC 92017R01). Five-year site reviews are conducted to document the exclusion of wildlife and the natural attenuation of contaminants.

4.5.4 Alternative B3: Landfill (On-Post Landfill)

Alternative B3 is a containment alternative that was developed for all three medium groups within the Biota Exceedance Category. The major components of Alternative B3 are the following:

- Construction of a centralized, on-post landfill facility with multiple landfill cells

- Excavation of soils exceeding Biota SEC

- Placement of excavated soils in the landfill and backfill of excavations with clean borrow material

- Long-term operations and maintenance (O&M) of the on-post landfill including cap maintenance, leachate treatment, and monitoring.

Section 4.1 of the Technology Description Volume describes the conventional excavation and dredging of contaminated soils. The choice of specific equipment is primarily based on site-specific needs. For example, scrapers may be effectively used to remove surficial soils, but are not applicable to removing contaminated soils from the Ditches/Drainage Areas Medium Group. The excavation or dredging plan developed for biota exceedance sites focuses on minimizing, to the extent possible, the impacts on biota and evaluates mitigation measures (e.g., determination of the appropriate season to excavate, determination of procedures for relocation of biota prior to excavation). During excavation, dust-control measures are implemented, in particular for the excavation of widespread areas of the Surficial Soils Medium Group. The excavation is backfilled with on-site borrow material and compacted to prevent future subsidence. The site is then regraded and revegetated with native grasses in accordance with a refuge management plan. Runoff controls may have to be implemented until the site is fully reclaimed.

Section 4.6.6 describes the centralized on-post landfill facility, including construction and operation. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the backfill. In addition, leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

4.5.5 Alternative B5a: Caps/Covers (Clay/Soil Cap) with Consolidation

Alternative B5a is a containment alternative that was modified for the Ditches/Drainage Areas Medium Group. Instead of capping the contaminated soils in place, the soils are consolidated in Basin A for containment. The major components of Alternative B5a are the following:

- Excavation of soils exceeding Biota SEC
- Consolidation of excavated soils in Basin A as grading fill prior to installation of a clay/soil cap
- Backfill of excavations with clean borrow material

The biota exceedance volume is excavated with conventional earth-moving equipment as discussed in Section 4.1 of the Technology Description Volume. During excavation, dust-control measures are implemented. The excavations are backfilled with borrow materials and revegetated with native grasses. Runoff controls are implemented, as needed, during excavation and revegetation.

As discussed in Section 6.2 of the Technology Description Volume, compacted clay/soil caps are constructed with design grades between 1.5 and 3 percent both to facilitate runoff and to reduce erosion damage. Therefore, the capping of Basin A requires the installation of more than 1 million CY of fill to achieve design grades. Instead of using borrow materials for grading fill, soils with low levels of contamination are consolidated and used as grading fill. As discussed in Section 3.1.4, the consolidation of soils for containment reduces the areas requiring long-term management and maintenance and increases the areas available for use as habitat. The consolidated soils form the subgrade for capping and are regraded and compacted to minimize subsidence. This alternative is based on the selection of Alternative 6f for Basin A.

The clay/soil cap for Basin A is designed and constructed in accordance with EPA design criteria as discussed in Section 6.2 of the Technology Description Volume. The clay/soil cap consists of (from bottom to top) a 2-ft-thick compacted low-permeability soil layer, a 1-ft-thick biota barrier of cobbles, and a 4-ft-thick soil/vegetation layer that includes 6 inches of topsoil over the areal extent of contaminated soils. The consolidated soils are used as grading fill beneath the compacted clay layer and form the subgrade for capping. The cap is revegetated, monitored, and maintained by mowing, fertilization, and repair of erosion damage.

4.5.6 Alternative B6: Direct Thermal Desorption (Direct Heating)

Alternative B6 is a thermal treatment alternative that was evaluated for the Lake Sediments and Ditches/Drainage Areas Medium Groups. The major components of Alternative B6 are the following:

- Excavation of soils exceeding Biota SEC and transportation of excavated soils to centralized thermal desorption facility

- Separation of oversize soils and any debris as a pre-treatment step followed by disposal of oversized material in an on-post landfill

- Treatment of organics in excavated soil by direct thermal desorption

- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment

- Backfill of treated soils

The excavated soils are transported to the centralized thermal desorption facility and thermally treated at 300°C as discussed in Section 4.6.24 (Alternative 13a). The solids processing rate is dependent on the moisture content of the solids feed, and varies from 1,250 to 1,970 bank cubic yards per day (BCY/day) for this alternative. Approximately 10 percent of the solids feed is entrained as particulates in the off-gas stream; however, most particulates are recovered and combined with the treated soils. Approximately 1 percent of the total solids feed is recovered from the scrubber blowdown along with salts from the scrubber (Figure 4.5-1). These particulates and salts are placed in the on-post landfill and contain elevated levels of inorganics, such as mercury and arsenic, that are volatilized during thermal desorption.

For sites in the Ditches/Drainage Areas Medium Group, the treated soils are backfilled on site. The organic carbon content of the soils is destroyed during thermal desorption, however, so topsoil is placed over the backfilled areas and revegetated with native grasses. The treated sediments from the Lake Sediments Subgroup are not backfilled, but are used as daily cover in the on-post landfill.

4.5.7 Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice)

Alternative B9 is a treatment alternative that was developed for the Surficial Soils and Ditches/Drainage Areas Medium Groups. The major components of Alternative B9 are the following:

- Treatment of organics in soils exceeding Biota SEC by landfarm/agricultural practices
- Monitoring through annual soil sampling and site reviews to detect potential contaminant migration to subsurface soils and to observe natural contaminant attenuation

The landfarm/agricultural practice process consists of using landfarming techniques either with farm machinery (ripper, plow, and disk) or a soil stabilizer along with seeding to facilitate stabilization and attenuation of OCPs in surface soils (0- to 1-ft depth interval). As discussed in Section 11.1 of the Technology Description Volume, the pesticides found in surficial soils have been shown to decrease in concentration over time when subjected to landfarm/agricultural practices. The landfarm technology does not provide intensive treatment of the contaminants present. It does, however, reduce the migration of contaminated dust, limit exposure to surface receptors, and allow the natural attenuation of contaminants to occur.

Farm machinery is used to till and seed the soil with native grasses as described in Section 11.1 of the Technology Description Volume. The soil hard pan is ripped where the ground is initially too hard for a plow to penetrate. A plow with 6- to 8-inch bottoms is used to cover the upper 2 inches of contaminated soil with uncontaminated soil from below the 0- to 2-inch depth interval. With the contaminated soil covered, dust dispersion and exposure of surface receptors is minimized. In the final step, a disk is used to break up and uniformly mix the soil. Fertilizer and mulch are applied, and a mixture of native grasses is seeded to facilitate development of a stable final grass stand (in accordance with a refuge management plan), aid soil conservation, and prevent dust dispersion.

A number of soil stabilizers that perform soils mixing are currently available. The soil stabilizers have the ability to uniformly mix an 8-ft width of soil to a depth up to 18 inches. They typically come equipped with an internal spray bar that enables water or nutrients to be added during soil mixing. The use of a soil stabilizer requires only one pass to effectively mix the soil. A typical soil stabilizer, at a working speed of 30 feet per minute (fpm), can till approximately 2.6 acres in a 10-hour day.

Long-term monitoring is conducted over the areas treated to observe the OCP levels over time and to observe the potential migration of contaminants to subsurface soils. The time frame for natural attenuation to achieve Biota PRGs is estimated at more than 30 years based on the range of half-lives for the primary OCP contaminants presented in the final RISR (EBASCO 1992a/RIC 92027R02). Five-year site reviews are conducted to document the decrease in OCP levels. For the Ditches/Drainage Areas Medium Group, the treatment of surficial soils by landfarm/agricultural practice does not address the contamination that occurs in depth intervals below 12 to 18 inches in some areas. These areas are addressed through fencing and habitat modification as discussed in Section 4.5.3.

4.5.8 Alternative B10: Caps/Covers (Clay/Soil Cap) with Consolidation; In Situ Biological Treatment (Aerobic Biodegradation)

Alternative B10 is a treatment alternative that was developed for the Lake Sediments Medium Group. The major components of Alternative B10 are the following:

- Excavation of highest levels of contamination, which includes isolated human health exceedances, from inlets of lakes
- Consolidation of excavated soils in Basin A as grading fill prior to installation of clay/soil cap
- Enhancement of natural attenuation/degradation in remaining sediments through in situ biological treatment
- Monitoring through annual soil sampling and site reviews to observe potential contaminant migration and attenuation

The inlets of the lakes are excavated using conventional earth-moving equipment such as backhoes. Section 4.1 of the Technology Description Volume contains a discussion of excavation methods. The vegetation in these areas is cleared prior to excavation, and dust controls are not required due to the high moisture content of the excavated soils. Temporary sheet-pile walls are used to control surface water. The excavated areas are backfilled with topsoil, and the wetlands are restored. As discussed in Section 4.5.2, the excavated soils are consolidated within Basin A as grading fill prior to the installation of a clay/soil cap for Basin A. The consolidated soils form

the subgrade of a clay/soil cap for Basin A. This alternative is based on the selection of Alternative 6f for Basin A.

The in situ biological treatment of lake sediments consists of optimizing conditions within the lake sediments to enhance biodegradation. The primary variables to be optimized are oxygen and nutrient availability. The primary organic contaminants of concern in the Southern Lakes, aldrin and dieldrin, have not been conclusively shown to biodegrade. However, recent advances in biodegradation of large chlorinated molecules such as PCBs indicate that biodegradation of chlorinated pesticides may be viable in the near future. Accordingly, this technology is evaluated for the Lake Sediments Medium Group as discussed in Section 11.4 of the Technology Description Volume.

An in situ biological treatment system for sediments consists of a mechanism to control oxygen concentrations and a mechanism to add macro- and micro-nutrients. Due to the constant flow of water in the lake over the sediments, the addition of the nutrients must be isolated from the water flow. In the case of oxygen, this can be accomplished by inserting a physical barrier between the sediments and the main body of the water. Relatively insoluble nutrients can be used that do not immediately dissolve and move into the water phase. A serious problem that may be encountered when adding nutrients to a lake system is eutrophication. (A lake system can become eutrophic when excess nutrients have been added. The resulting biomass kills larger organisms due to lack of oxygen.) This problem is minimized by reducing the amount of sunlight reaching the nutrient-enhanced portion of the lake, or by adding nutrients to small areas of the lake at a time.

Two vendor approaches for remediating lake sediments using bioremediation were considered. Both approaches isolate the sediments from the surrounding water so that conditions can be controlled to maximize biodegradation. The first approach uses a caisson-enclosed system consisting of a raking mechanism to aerate the sediments along with a submerged blanket to prevent resuspension of the contaminants into the water. The second approach involves adding

dense, insoluble nutrient and oxygen sources that settle to the bottom where they are used by organisms present in the sediment. The oxygen and nutrient supplies aid in the multiplication of organisms capable of degrading specific contaminants without disturbing the sediment, lessening the possibility of resuspending contaminants.

During the treatment of the lake sediments by in situ biological treatment, sediment sampling is conducted to detect potential contaminant migration, to observe the rate of attenuation/degradation, and to assess the continued nutritional requirements of the microbial community. Five-year site reviews are conducted during this process to document the treatment of the sediments.

4.5.9 Alternative B11: In Situ Thermal Treatment (Surface Soil Heating)

Alternative B11 is a treatment alternative that was developed for the Surficial Soils Medium Group. The major component of Alternative B11 is the following:

- Treatment of organics in soils exceeding Biota SEC by in situ surface soil heating

The surface soil heating process, or Enhanced Surface Soil Vapor Extraction Process (ESSVEP), heats soil within 12 inches of the surface to temperatures at which OCPs are readily volatilized, collected, and treated. As discussed in Section 8.1 of the Technology Description Volume the treatment system is made up of several components: soil heating assembly, heater support structure, vapor collection and treatment system, and power supply . The soil heating assembly and impermeable cover are designed so that the entire unit can be moved quickly from one site to another. The vapor collection system ensures that the contaminants released from the soil flow to a vapor treatment system where they are collected and/or destroyed.

During heating, vapors are collected from beneath the soil heating assembly to prevent vaporized contaminants from escaping to the atmosphere or moving to the surrounding soil. The vapor collection systems collect the vapors, steam, and volatilized constituents and transport them to the vapor treatment system. The off gases are treated by catalytic incineration. Depending on

the concentration of organic contaminants in the collected gas entering the incinerator, additional fuel may have to be added to the incinerator. The vent gases are scrubbed to remove hydrochloric acid formed during incineration and then quenched.

Surface soil heating is a site-specific technology currently being developed by Shell. The technology has progressed through pilot-scale testing; however, full-scale implementation has yet to be completed. Given the scale of the remediation that would be required, several modular units are necessary to achieve effective treatment in a timely manner. Projections of full-scale implementation by Shell include construction of 50- by 50-foot modules capable of treating the first 12 inches of surface soil to the operating temperature of 250°C. These units can treat 3.5 acres annually. Treating the soil by surface soil heating reduces organic content of the soil as well as moisture content, requiring the addition of topsoil to effectively maintain a vegetative cover.

4.5.10 Biota Alternatives for Human Health Exceedance Category Medium Groups

Most of the biota alternatives described above also apply to the biota exceedance portions of Human Health Exceedance Category medium groups. For example, Alternative B6: Direct Thermal Desorption (Direct Heating) is applied to the biota exceedance portion of the Basin A Medium Group in conjunction with Alternative 13: Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification). Four alternatives were developed for the biota exceedance portions of Human Health Exceedance Category medium groups, but they are not used for the Biota Exceedance Category medium groups. These alternatives consist of variations on two of the alternatives discussed above and are as follows:

- Alternative B5: Caps/Covers (Clay/Soil Cap)—Containment of biota exceedance areas in place with compacted low-permeability soil, biota barrier, and cover soil/vegetation layers as discussed in Section 4.6.8 (Alternative 5)
- Alternative B5b: Caps/Covers (Clay/Soil Cap) with Modifications to Existing System—Installation of additional layers of cap/cover to augment existing IRA cover and improve long-term performance as described for human health exceedances in Section 4.6.9 (Alternative 5a)

- Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating)—In Situ RF heating of biota exceedance area and treatment of off gases as described for human health exceedances in Section 4.6.30 (Alternative 19a)

- Alternative B11b: In Situ Thermal Treatment (Surface Soil Heating, RF/Microwave Heating)—In situ surface soil heating and RF heating of biota exceedance areas and treatment of off gases as described for human health exceedances in Section 4.6.31 (Alternative 19b)

- Alternative B12: Direct Soil Washing (Solvent Washing)—Excavation of biota exceedance areas and treatment by solvent washing as described in Section 4.6.20 (Alternative 8a)

4.6 ALTERNATIVES FOR THE HUMAN HEALTH EXCEEDANCE CATEGORY

Fourteen distinct alternatives were retained in the DSA for the Human Health Exceedance Category. As discussed in Section 4.1, the alternatives for the Human Health Exceedance Category subgroups were modified to account for consolidation of contaminated soils and the treatment of principal threats. In addition, alternatives for the Former Basin F, Shell Trenches, and Section 36 Lime Basins Subgroups were modified to account for the presence of soil covers installed during IRAs. Based on these modifications, a total of 33 alternatives are evaluated for the human health medium groups.

In the DSA, the human health alternatives included generalized agent, UXO, and biota alternatives developed to address potential agent, potential UXO, and biota exceedances. In the DAA, specific alternatives to address agent, UXO, and biota exceedances were developed for each subgroup. These agent, UXO, and biota alternatives are not listed in the following sections, but are described in Sections 10 through 19 to avoid confusion.

4.6.1 Alternative 1: No Additional Action (Provisions of FFA)

A No Action Alternative was developed for all 21 medium groups/subgroups within the Human Health Exceedance Category. The major components of Alternative 1 are the following:

- No further action beyond the FFA restrictions and existing or planned IRAs (this alternative includes long-term maintenance of soil covers installed during IRAs)

- Annual soil monitoring and 5-year site reviews to observe natural contaminant attenuation and potential migration of contaminants

The provisions of the FFA (EPA et al. 1989/RIC 89068R01) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or related remediation activities. In addition, contaminant levels are monitored on an annual basis to observe natural contaminant attenuation and potential contaminant migration. Changes in the site conditions are documented through 5-year site reviews. The time frame for natural attenuation to achieve Human Health and Biota PRGs is considered to be more than 30 years based on the range of half-lives for the predominant organic contaminants presented in the final RISR (EBASCO 1992a/RIC 92017R01).

4.6.2 Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA)

This alternative treats the principal threat volume by thermal desorption and initiates no additional action for the remaining soils. This alternative is applicable to the Basin A, Former Basin F, Chemical Sewers, South Plants Ditches, and South Plants Balance of Areas Subgroups. The major components of Alternative 1a are the following:

- Separation of oversize soils and debris as a pre-treatment step
- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.23 (Alternative 13)
- Disposal of oversized materials in the on-post landfill
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment and backfill of treated soils
- No further action for remaining soils beyond the FFA restrictions and existing or planned IRAs (including long-term maintenance of soil covers installed during IRAs)
- Annual monitoring and 5-year site reviews to observe natural contaminant attenuation and potential migration of contaminants in remaining soils

The soils forming the principal threat volume are excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Description Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. For Basin A, dewatering is required prior to excavation to allow the excavation of soils near the water table.

The excavated soils are transported to the centralized thermal desorption facility and thermally treated at 300°C. The processing rate is dependent on the moisture content of the solids feed, but is generally about 2,00 BCY/day with a 65 percent online factor for the principal threat volumes since most of these soils are near saturation. Approximately 1 percent of the solids feed is collected as particulates and salts from the emissions control equipment and placed in the on-post landfill. The treated soils are backfilled, but a layer of topsoil is placed over the backfilled areas since the thermal desorption process removes the organic content of soils. The topsoil is revegetated with native grasses in accordance with a refuge management plan.

The provisions of the FFA (EPA et al. 1989/RIC 89068R01) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or related remediation activities. In addition, contaminant levels in the remaining soils are monitored on an annual basis to observe natural contaminant attenuation and potential contaminant migration. The changes in site conditions over time are documented through 5-year site reviews. The time frame for natural attenuation to achieve Human Health and Biota PRGs is estimated to be more than 30 years based on the range of half-lives for the predominant organic contaminants presented in the final RISR (EBASCO 1992a/RIC 92017R01).

4.6.3 Alternative 1b: Direct Thermal Desorption (Direct Heating) and Direct Solidification/ Stabilization (Cement-Based Solidification) of Principal Threat Volume; No Additional Action (Provisions of FFA)

This alternative consists of treating soils containing organic and inorganic contaminants above the principal threat criteria by thermal desorption and solidification/stabilization and by initiating

no additional actions for the remaining soils. Alternative 1b is applicable to the South Plants Central Processing Subgroup. The major components of Alternative 1b are the following:

- Excavation of principal threat volume and treatment of organics by direct thermal desorption and of inorganics by direct solidification/stabilization at a centralized facility as discussed in Section 4.6.23 (Alternative 13)

- Separation of oversize soils and debris as a pre-treatment step followed by disposal of oversized materials in the on-post landfill

- Disposal of particulates and soils from the scrubber blowdown of the thermal desorption emission control equipment and backfill of treated soils without inorganic exceedances

- Backfill of solidified soils with placement of 4 ft of thermally desorbed soils as cover to preserve integrity of solidified materials and prevent freeze/thaw damage

- Long-term monitoring of solidified soils to observe durability and maintenance of overlying cover

- No further action for remaining soils beyond the FFA restrictions

- Annual monitoring and 5-year site reviews to observe natural contaminant attenuation and potential migration of contaminants in remaining soils

The principal threat volume is excavated using conventional earth-moving equipment as described in Section 4.1 of the Technology Description Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors is controlled. Soils containing organics above the principal threat criteria are treated by thermal desorption, while soils with inorganics above the principal threat criteria are treated by direct solidification/stabilization. Both treatment facilities are sited in the vicinity of South Plants.

The soils are thermally desorbed at 300°C and a rate of approximately 2,000 BCY/day with a 65 percent online factor since most principal threat soils are near saturation. However, the processing rate is dependent on the moisture content of the solids feed. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment. These materials are placed in the on-post landfill. Treated soils without inorganic exceedances of the principal threat criteria are backfilled. Since thermal desorption removes the organic

content of soils during processing, a layer of topsoil is placed over the backfilled soils and is revegetated with native grasses.

Soils with inorganics above the principal threat criteria are solidified by adding cement at a ratio of 0.2 tons/ton of soil. The solidified soils are backfilled on post. Four feet of thermally desorbed soils are placed over the solidified soils to prevent freeze/thaw damage. The durability of the solidified soils is monitored, and the cover is maintained by repairing any erosion damage.

The provisions of the FFA (EPA et al. 1989/RIC 89068R01) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or related remediation activities. In addition, contaminant levels in the remaining soils are monitored on an annual basis to observe natural contaminant attenuation and potential contaminant migration. The changes in site conditions over time are documented through 5-year site reviews. The time frame for natural attenuation to achieve Human Health and Biota PRGs is considered to be more than 30 years based on the range of half-lives for the predominant organic contaminants presented in the final RISR (EBASCO, 1992a/RIC 92017R01).

4.6.4 Alternative 2: Access Restrictions (Modifications to the FFA)

Alternative 2 is a no action/institutional controls alternative that applies to the Basin F Wastepile Medium Group and the Secondary Basins, Basin F Exterior, Sanitary/Process Water Sewers, Chemical Sewers, Sanitary Landfill, Buried Sediments, and Section 36 Balance of Areas Subgroups. The major components for Alternative 2 are the following:

- Installation of fencing and modifications to the FFA to limit human contact with contaminants; habitat modifications to address residual contamination above Biota PRGs
- Annual monitoring and 5-year site reviews to observe natural contaminant attenuation and potential contaminant migration and maintenance of soil covers installed during IRAs

The exposure of humans to contaminated soil is reduced through both land-use restrictions and modifications to worker practices. As discussed in Section 3.1 of the Technology Description Volume, public education programs are initiated to ensure that RMA visitors and workers are aware of the access restrictions and that they observe the controls. Construction of a 6-ft-high chain-link perimeter fence with posting around each site further reduces direct human contact with contaminated soil as discussed in Section 4.5.3 for biota exclusion (Alternative B2). For the Sewer Systems Medium Group, access is restricted through modifications to worker practices, as described in the FFA, and the plugging of sewer pipes. Biota exclusion measures, consisting of habitat management to reduce biota exposure to contaminants, are discussed in Section 4.5.3. Annual soil monitoring is used to observe natural attenuation and detect potential contaminant migration, and 5-year site reviews are used to document the changes to site conditions. The time frame for natural attenuation to achieve Human Health and Biota PRGs is considered to be more than 30 years based on the range of half-lives for the predominant organic contaminants presented in the RISR (EBASCO 1992a).

4.6.5 Alternative 2a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modifications to the FFA)

Alternative 2a combines an institutional control alternative with the direct thermal desorption of principal threat volumes. This alternative applies to the Former Basin F and Chemical Sewers Subgroups. The major components for Alternative 2a are the following:

- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.23 (Alternative 13)

- Separation of oversize soils and debris as a pre-treatment step followed by disposal of oversized materials in the on-post landfill

- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment and backfill of treated soils

- Installation of fencing and modifications to the FFA to limit human contact with contaminants; habitat modifications to address residual contamination above Biota PRGs

- Annual monitoring and 5-year site reviews to observe natural contaminant attenuation and potential contaminant migration and maintenance of soil covers installed as part of IRAs

The soils containing organic contaminants above the principal threat criteria are excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Description Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled.

The excavated soils are transported to the centralized thermal desorption facility and thermally treated at 300°C. The processing rate is dependent on the moisture content of the solids feed, but is generally 2,000 BCY/day with a 65 percent online factor for these principal threat volumes since most of these soils are near saturation. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post landfill. The treated soils are backfilled, but a layer of topsoil is placed over the backfilled areas since thermal desorption removes the organic content of soils during processing. The topsoil is revegetated with native grasses.

The exposure of humans to residual contaminated soil is reduced through both land-use restrictions and modifications to worker practices. Construction of a 6-ft-high chain-link perimeter fence with posting around each site further reduces direct human contact with contaminated soil as discussed in Section 4.5.3 for biota exclusion (Alternative B2). For the Sewer Systems Medium Group, access is restricted through modifications to worker practices and the plugging of sewer pipes. Biota exclusion measures, consisting of habitat management to reduce biota exposure to contaminants, are discussed in Section 4.5.3. Annual soil monitoring of the balance of areas is used to observe natural attenuation and detect potential migration of contaminants, and changes to site characteristics are documented with 5-year site reviews. The time frame for natural attenuation to achieve Human Health and Biota PRGs in the remaining soils is estimated to be more than 30 years based on the range of half-lives for the predominant organic contaminants presented in the final RISR (EBASCO 1992a/RIC 92017R01).

4.6.6 Alternative 3: Landfill (On-Post Landfill)

Alternative 3 is a containment alternative that applies to the Basin A, Sanitary Landfills, South Plants, Buried Sediments/Ditches, and Undifferentiated Medium Groups as well as to the Sanitary/Process Water Sewers Subgroup in the Sewer Systems Medium Group. Section 3.1.3 discusses the construction of a centralized landfill to contain up to 6,000,000 BCY of soil and debris. The major components of Alternative 3 are the following:

- Construction of a centralized on-post landfill facility with multiple landfill cells
- Excavation of soils exceeding the Human Health SEC and transportation to the on-post landfill
- Placement of excavated soils in the on-post landfill and backfill of excavations with clean borrow material
- Long-term O&M of the on-post landfill including cap maintenance, leachate treatment, and monitoring

Section 4.1 of the Technology Description Volume discusses the conventional excavation of contaminated soils and the choice of specific excavation equipment. During excavation, dust is suppressed and volatile organic and odor emissions controlled. Dewatering is required for the Basin A and Section 36 Balance of Areas Subgroups prior to excavation to allow the removal of soils near the water table. Following excavation, the site is backfilled with borrow material obtained on post and compacted to prevent future subsidence. The site is then covered with 6 inches of topsoil, regraded, and revegetated with native grasses. Runoff controls may have to be implemented until the site is fully reclaimed.

The number of cells in the landfill depends on the amount of contaminated soil to be disposed. The cells may be constructed and classified based on their cover and liner systems and the types of wastes to be disposed. Depending on the concentrations and leachability of contaminants, contaminated soil may be placed in either a hazardous waste landfill cell, which is constructed according to RCRA requirements, or in a solid waste landfill cell. The on-post landfill contains separate cells for hazardous waste and solid waste.

A RCRA hazardous waste landfill cell is constructed with a double-composite liner system consisting of at least two synthetic liners and two low-permeability soil liners. This system also contains leachate collection and leak detection systems. The cover system for the hazardous waste landfill cell is constructed with a synthetic/soil low-permeability barrier, an infiltration drainage system, a gas collection system, and a soil and topsoil cover layer. The solid waste landfill cell is constructed in a manner similar to the hazardous waste cell, but under less stringent conditions. Most of the contaminated soils are placed in a hazardous landfill cell, but the surface debris excavated during the removal of contaminated soils is placed in solid waste cell. Section 6.5 of the Technology Description Volume presents a discussion of both types of landfill cells; the construction and monitoring of a hazardous waste landfill is summarized below.

The cover system acts as an impermeable cap above the waste to isolate the contaminated material from the surface environment. Although the material being disposed is compacted as it is placed in the landfill cell, the cap is designed to accommodate any settlement or subsidence within or below the cell and consists of several individual layers that include the following (listed from top to bottom):

- 4-ft-thick upper soil/vegetation layer including 6 inches of topsoil to allow revegetation of the cover and prevent freeze/thaw damage to the low-permeability layer
- 1-ft-thick biota barrier layer of cobbles to prevent intrusion by burrowing animals, which is underlain by a geosynthetic filter
- 1-ft-thick drainage layer to intercept water percolating through the upper layers of the cap and transport it out of the cover
- Composite low-permeability layer comprised of a flexible membrane liner (FML) and a 2-ft-thick compacted low-permeability soil cap
- Gas vent layer with a gas collection and venting system constructed of a geonet or granular fill and perforated high-density polyethylene (HDPE) pipe surrounded by a filter fabric blanket

The liner system consists of a double-composite liner system that isolates the contaminated soils and leachate from the underlying subsurface environment. The layers of the composite liner typically consist of two synthetic FMLs and two 3-ft-thick low-permeability soil liners. The synthetic liners must be chemically compatible with the waste contaminants and any leachate generated. Commonly used synthetic liner materials include HDPE, chlorinated polyethylene (CPE), chlorosulfonated polyethylene (CSPE), and polyvinyl chloride (PVC). The low-permeability soil liners are constructed such that the permeability of the liner is less than 1×10^{-7} centimeters per second (cm/sec). The leachate collection and removal system is located inside the cell, directly above the primary liner. The system includes either granular material or a geonet. The leachate is collected in the sumps and transported to an on-post groundwater or wastewater treatment facility for treatment. A leak detection layer is located below the primary composite liner to ensure that leachate does not migrate below the secondary composite liner.

Groundwater monitoring is conducted around the landfill, and 24-hour security provided to prevent unwarranted intrusion and to preserve the integrity of the landfill. Monitoring equipment is continuously inspected to ensure reliability. During operation, leachate from the landfill is collected, sampled, and treated on post at one of the existing groundwater treatment facilities. When the landfill is filled to capacity, the area is completely contained with a cap, regraded, revegetated, mowed, and fertilized. The performance of a RCRA-type landfill is monitored and maintained for a minimum of 30 years following closure.

4.6.7 Alternative 3a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill)

Alternative 3a combines the treatment of the principal threat volume by thermal desorption with the containment of the remaining exceedance volume in the on-post landfill. This alternative applies to the Chemical Sewers Subgroup. The major components of Alternative 3a are the following:

- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.23 (Alternative 13)

- Separation of oversize soils and debris as a pre-treatment step followed by disposal of oversized materials in the on-post landfill
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment into the landfill and backfill of treated soils
- Construction of a centralized on-post landfill facility with multiple landfill cells
- Excavation of the remaining soils exceeding the Human Health SEC and transportation to the on-post landfill
- Placement of excavated soils in the on-post landfill and backfill of excavations with clean borrow material
- Long-term O&M of the on-post landfill including cap maintenance, leachate treatment, and monitoring

Soils above principal threat volumes are excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Description Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. The excavation of the sewers entails the removal of 340,000 BCY of overburden soils. Overburden soils are stockpiled on site for use as backfill.

The excavated principal threat soils are transported to the centralized thermal desorption facility and thermally treated at 300°C. The processing rate is dependent on the moisture content of the solids feed, but is generally 2,000 BCY/day with a 65 percent online factor for the principal threat volumes since most of these soils are near saturation. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post landfill. The treated soils are backfilled. The site is restored to original grade and revegetated following the backfilling of the remaining overburden soils.

The remaining exceedance volume of soils is excavated using conventional equipment as discussed in Section 4.1 of the Technology Description Volume. During excavation, dust is suppressed and emission of volatiles and odors are controlled. Dewatering is required to allow

the removal of soils from near the water table. Following excavation, the site is backfilled with borrow material including overburden obtained on post and compacted to prevent future subsidence. The site is then regraded and revegetated with native grasses. Runoff controls are implemented, as needed, during excavation and revegetation. The centralized landfill facility is as discussed in Section 4.6.6. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. Leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

4.6.8 Alternative 5: Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Walls)

Alternative 5 is a containment alternative that is applicable to the Sanitary Landfills Medium Group and the Hex Pit and Buried M-1 Pits Subgroups. The major components of Alternative 5 are the following:

- Containment of soils exceeding the Human Health SEC by installing a clay/soil cap
- Construction of a slurry wall to contain contaminants and control migration of contaminated groundwater
- Monitoring through 5-year site reviews and maintenance operations to determine the effectiveness of the containment systems

The clay/soil cap consists of three primary layers. In general, the uppermost layer is the same as the soil/clay cover, which is described in Section 4.3.2. From top to bottom, the clay/soil cap consists of the following:

- 4-ft top soil/vegetation layer consisting of clean borrow material capable of supporting vegetation and 6 inches of topsoil that act to minimize erosion and promote drainage
- 1-ft biota barrier layer made up of cobbles to protect the underlying clay layer from burrowing animal intrusion
- 2-ft low-permeability compacted soil layer

Section 6.2 of the Technology Description Volume discusses the clay/soil cap in more detail. The top layer of the cap consists of 4 ft of clean borrow material, including 6 inches of topsoil to sustain vegetation and to prevent freezing and thawing from damaging the underlying low-permeability soil layer. To prevent ponding of rainwater due to irregularities in the top layer of the cap, it is constructed with a slope of 1.5 to 3 percent. Native grasses used for revegetation are selected to impede erosion and to allow surface runoff from major storm events.

The biota barrier consists of a 1-ft-thick layer of cobbles to prevent the intrusion of burrowing animals into the lower layers of the cap. The barrier consists of large, tightly packed cobbles. Gravel is used to fill the voids within the cobble layer. Over time, soil from the overlying soil layer infiltrates and fills the voids, but the effectiveness of neither layer is compromised.

The final layer of the clay/soil cap is the low-permeability soil layer. This layer provides long-term minimization of infiltration into the contaminated soil unit. The low-permeability soil layer is constructed such that the hydraulic conductivity of the unit is no greater than 1×10^{-7} cm/sec. The compacted layer is 2-ft thick and is constructed as specified by the EPA for hazardous waste cap design (Technology Description Volume). The layer is installed as a series of 6-inch lifts to allow any localized inconsistencies in one lift to be "sealed" by another.

Slurry walls are installed around sites in conjunction with the placement of a clay/soil cap to form an isolation cell around the contaminated soil. The installation of a slurry wall entails the excavation of a trench with a backhoe, extended-reach backhoe, or a clamshell as discussed in Section 6.3 of the Technology Description Volume. A slurry of bentonite and water is pumped into the trench to prevent the walls of the trench from collapsing. The fill material, consisting of a soil and bentonite mixture, is then placed into the slurry-filled trench. In general, the soils excavated from the trench are amended with bentonite and used as slurry wall backfill; however, in some instances the excavated soils are used as grading fill for the cap, and clean borrow material is used as slurry wall backfill. Installation of the slurry wall prior to the soil cap allows the compacted soil layer to be "keyed" into the top of the slurry wall. The slurry mixture

consists of dry bentonite mixed with water to form a pumpable mixture. The ratio of bentonite to water as well as the specifications for the mixture of soils and bentonite for the fill material are based on laboratory-scale engineering and compatibility testing. The soils used in the soil-bentonite backfill generally should be well graded with a large percentage of fine-grained materials.

To control groundwater migration, a groundwater removal system is installed in conjunction with the slurry wall. When a slurry wall surrounds a given site, the hydraulic controls maintain a reduced hydraulic head to ensure that groundwater moves from the outside of the slurry wall system to the inside. The groundwater removal system is designed based on site-specific conditions. The extraction well system is designed to be flexible in meeting increased or decreased pumping demands and to ensure that the required hydraulic gradient may be established and maintained.

The long-term maintenance of the low-permeability soil cap consists of mowing the vegetative cover and repairing erosion damage. Five-year site reviews are conducted to document the effectiveness of the containment system. The water removed from the dewatering system is pumped to the CERCLA Wastewater Treatment Plant.

4.6.9 Alternative 5a: Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Walls) with Modifications to Existing System

Alternative 5a is a containment alternative that is applicable to the Shell Trenches Subgroup. The major components of Alternative 5a are the following:

- Containment of soils exceeding the Human Health SEC by modifying the existing soil cover from the IRA

- Construction of a slurry wall to augment the existing vertical barrier installed as part of groundwater migration control barrier

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment systems

The existing soil cover constructed during the IRA is augmented by installing a low-permeability soil cap to improve the long-term performance of the existing cover. Section 4.6.8 provides a discussion of a clay/soil cap. The modified clay/soil cap consists of the same layers as described in Section 4.6.8, except that the uppermost 2 ft of the existing soil cover are removed, stockpiled, and incorporated into the soil/vegetation layer. Section 4.6.8 describes the installation of the slurry wall and operation of the dewatering system.

4.6.10 Alternative 5b: Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Walls) with Consolidation

Alternative 5b is a containment alternative that is applicable to the Complex Trenches Subgroup. Alternative 5b is similar to Alternative 5: Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Walls) except that contaminated soils from the edge of the site are consolidated within the disposal trench areas (as defined by geophysical anomalies) as grading fill prior to containment of the disposal trench. The major components of Alternative 5b are as follows:

- Containment of disposal trenches by installing a low-permeability soil cap
- Construction of a slurry wall around the disposal trenches to contain contaminants and control migration of contaminated groundwater
- Consolidation of soils with human health exceedances outside of trench boundaries on top of disposal trenches as grading fill prior to containment
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

A low-permeability soil cap and slurry wall with a dewatering system are installed and operated as discussed in Section 4.6.8. The shallow (i.e., near-surface) soils outside the disposal trench areas contain much lower levels of contamination than the disposal trenches. To reduce the areas requiring capping, these soils are consolidated within the disposal trench areas as grading fill. The consolidated soils serve as the subgrade for the cap and are used to achieve the design grades for caps. The excavated areas are revegetated after the placement of the topsoil layer.

4.6.11 Alternative 6: Caps/Covers (Clay/Soil Cap)

Alternative 6 is a containment alternative that was developed for the Basin A, South Plants, and Undifferentiated Medium Groups and the Secondary Basins, Basin F Exterior, and Buried Sediments Subgroups. The major components of Alternative 6 are the following:

- Containment of soils exceeding the Human Health SEC by installing a clay/soil cap
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment systems

The low-permeability soil cap is designed and constructed as described in Section 4.6.8 (Alternative 5). The low-permeability soil cap is maintained and inspected annually, and any erosion damage is repaired. Five-year site reviews are conducted to document the effectiveness of the containment system.

4.6.12 Alternative 6a: Direct Thermal Desorption (Direct Heating) and Direct Solidification/ Stabilization (Cement-Based Solidification) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap)

Alternative 6a combines containment and treatment processes and was evaluated for the South Plants Central Processing Subgroup. Alternative 6a treats the organic principal threat volume by thermal desorption and the inorganic principal threat volume by solidification/stabilization with the remaining exceedance volumes contained with a cap. The major components of Alternative 6a are the following:

- Excavation of principal threat volume and treatment of organics by direct thermal desorption and of inorganics by direct solidification/stabilization (at a centralized facility as discussed in Section 4.6.24)
- Separation of oversize soils and debris as a pre-treatment step followed by disposal of oversized materials in the on-post landfill
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment and backfill of treated soils without inorganics exceedances
- Backfill of solidified soils containing inorganics with placement of 4-ft of thermally desorbed soils as cover to preserve integrity of solidified materials and prevent freeze/thaw damage

- Long-term monitoring of solidified soils to observe durability and maintenance of overlying cover

- Containment of remaining soils exceeding the Human Health SEC by installing a clay/soil cap

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

The soils comprising the principal threat volume are excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Description Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled.

Soils containing organics exceeding principal threat criteria are processed at 300°C at a rate of approximately 2,000 BCY/day with a 65 percent online factor since most principal threat soils are near saturation. However, the processing rate is dependent on the moisture content of the solids feed. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment. These materials are placed in the on-post landfill. Treated soils without inorganic exceedances of the principal threat criteria are backfilled. Since thermal desorption removes the organic content of soils during processing, a layer of topsoil is placed over the backfilled soils and is revegetated with native grasses.

Soils with inorganics above the principal threat criteria are solidified by adding cement at a ratio of 0.2 tons/ton of soil. The solidified soils are backfilled on post. Four feet of thermally desorbed soils are placed over the solidified soils to prevent damage from freeze/thaw conditions. The durability of the solidified soils is monitored, and the cover is maintained by repairing any erosion damage.

The clay/soil cap is designed and constructed as described in Section 4.6.8 (Alternative 5). The clay/soil cap is maintained through inspections and any erosion damage is repaired. Five-year site reviews are conducted to document the effectiveness of the containment system.

4.6.13 Alternative 6b: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Consolidation

Alternative 6b combines containment and treatment processes and was developed for the South Plants Ditches and South Plants Balance of Areas Subgroups. The principal threat volume is thermally desorbed and the remaining exceedance volume is consolidated as grading fill prior to installation of the low-permeability soil cap. The major components of Alternative 6b are the following:

- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.24 (Alternative 13a)
- Separation of oversize soils and debris as a pre-treatment step followed by disposal of oversized materials in the on-post landfill
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment and backfill of treated soils
- Excavation of remaining soils with human health exceedances and backfill of excavations with borrow materials
- Consolidation of excavated soils in the South Plants Central Processing Area as grading fill prior to installation of low-permeability soil cap

The soils comprising the principal threat volume are excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Description Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled.

The excavated principal threat volume of soil is transported to the centralized thermal desorption facility and thermally treated at 300°C. The processing rate is dependent on the moisture content of the solids feed, but is generally 2,000 BCY/day with a 65 percent online factor for these principal threat volumes since most of these soils are near saturation. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post landfill. The treated soils are backfilled, but a layer of topsoil is placed over the backfilled areas since thermal desorption removes the organic content of soils during processing. The topsoil is revegetated with native grasses.

The remaining soils exceeding the Human Health SEC are excavated and consolidated in the South Plants Central Processing Area. The consolidated soils are used as grading fill prior to capping to bring the area to the design grades for caps as discussed in Section 4.5.5. The excavations are backfilled with borrow materials and revegetated with native grasses. This alternative is based on the selection of Alternative 6a for South Plants Central Processing Area.

4.6.14 Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Modifications to Existing System

Alternative 6c was developed for the Former Basin F Subgroup, and combines a containment option with thermal desorption of the principal threat volume. Following thermal desorption, the remaining exceedance volume is contained in a low-permeability soil cap that augments the existing cover. The major components of Alternative 6c are the following:

- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.24 (Alternative 13a)
- Separation of oversize soils and debris as a pre-treatment step followed by disposal of oversized materials in the on-post landfill
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment and backfill of treated soils
- Containment of remaining soils exceeding the Human Health SEC through modifications to existing cover installed as part of the IRA
- Monitoring through 5-year site reviews and maintenance operations to determine the effectiveness of the containment system

The soils forming the principal threat volume are excavated using conventional earth moving equipment as discussed in Section 4.1 of the Technology Description Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled.

The excavated soils are transported to the centralized thermal desorption facility and thermally treated at 300°C. The processing rate is dependent on the moisture content of the solids feed, but is generally 2,000 BCY/day with a 65 percent online factor for the principal threat volumes

since most of the soils are near saturation. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post landfill. The treated soils are backfilled, but a layer of topsoil is placed over the backfilled areas since thermal desorption removes the organic content of soils during processing. The topsoil is revegetated with native grasses.

The existing soil cover is augmented with the installation of a low-permeability soil cap as described in Section 4.6.8. The modified cap consists of the same components as described in Section 4.5.5, however, the uppermost 2 ft of the existing cover is removed prior to capping. The excavated material is used in the soil/vegetation layer. The clay/soil cap is maintained and inspected annually, any erosion damage is repaired, and 5-year site reviews are conducted.

4.6.15 Alternative 6d: Caps/Covers (Clay/Soil Cap) with Modifications to Existing System

Alternative 6d is a containment alternative developed for the Former Basin F and Section 36 Lime Basins Subgroups. The major components of Alternative 6d are the following:

- Containment of soils exceeding the Human Health SEC by modifying the existing soil cover

- Monitoring through 5-year site reviews and annual maintenance to determine the effectiveness of the containment system

The existing soil cover in both the Former Basin F and Section 36 Lime Basins Subgroups is augmented by installing a low-permeability soil cap to improve the long-term performance of the existing cover. Section 4.6.8 provides a discussion of a clay/soil cap. The modified clay/soil cap consists of the same layers as described in Section 4.6.8, except that the uppermost 2 ft of the existing cover are removed, stockpiled, and installed as part of the soil/vegetation layer.

4.6.16 Alternative 6e: Caps/Covers (Composite Cap)

Alternative 6e is a containment alternative that was developed for the Basin F Wastepile Medium Group. The major components of Alternative 6e are the following:

- Containment of the Basin F Wastepile soil by installing a composite cap

- Correction of the leachate collection problems in the Cell 2 sump of the wastepile

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system and to verify the collection and treatment of leachate from the wastepile

A composite cap is placed over the Basin F Wastepile to augment the existing cover on the wastepile. It is designed and constructed similarly to the landfill cover discussed in Section 4.6.6. The cap consists of compacted low-permeability soil, FML, biota barrier, and soil cover layers. The installation of the composite cap on the Basin F Wastepile interrupts exposure pathways and reduces the generation of leachate by reducing infiltration; however, continued collection and treatment of leachate is required in the long term. The cap is inspected and maintained annually and any erosion damage is repaired.

4.6.17 <u>Alternative 6f: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap)</u>

Alternative 6f involves the thermal desorption of the principal threat volume and the installation of a low-permeability soil cap over the remaining exceedance volume along with material consolidated into Basin A from other medium groups. This alternative was developed for the Basin A Medium Group. The major components of Alternative 6f are the following:

- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.23 (Alternative 13)

- Separation of oversize soils and debris as a pre-treatment step followed by disposal of oversized materials in the on-post landfill

- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment and backfill of treated soils

- Consolidation of lower-level contaminated soils from other sites into Basin A to serve as grading fill prior to cap construction

- Containment of remaining soils exceeding the Human Health SEC by installing a clay/soil cap

The soils forming the principal threat volume are excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Description Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled.

The excavated soils are transported to the centralized thermal desorption facility and thermally treated at 300°C. The processing rate is dependent on the moisture content of the solids feed, but is generally 2,000 BCY/day with a 65 percent online factor for the principal threat volumes since most of the soils are near saturation. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission equipment and placed in the on-post landfill. The treated soils are backfilled, but a layer of topsoil is placed over the backfilled areas since thermal desorption removes the organic content of soils during processing. The topsoil is revegetated with native grasses.

Approximately 1.2 to 1.8 million BCY of soils (depending on the final grade required) from other sites and/or borrow material obtained on post is used as grading fill to bring Basin A to a convex profile with a 1.5 to 3 degree slope (to promote drainage) prior to construction of the cap. The clay/soil cap is designed and constructed as described in Section 4.5.5 (Alternative B5a). The clay/soil cap is maintained through annual inspections, and any erosion damage is repaired. Five-year site reviews are conducted to document the effectiveness of the containment system.

4.6.18 Alternative 6g: Caps/Covers (Clay/Soil Cap) with Consolidation

Alternative 6g is a containment alternative that consists of consolidating contaminated soils prior to capping. It was evaluated for the Buried Sediments/Ditches Medium Group and Secondary Basins, Basin F Exterior, and Section 36 Balance of Areas Subgroups. The major components of Alternative 6g are the following:

- Excavation of soils exceeding the Human Health SEC

- Consolidation of excavated soils in Basin A as grading fill prior to installation of clay/soil cap

- Backfill of excavations with borrow materials

The human health exceedance soils are excavated with conventional earth-moving equipment as described in Section 4.1 of the Technology Description Volume and consolidated in Basin A. The consolidated soils are used as grading fill prior to capping to bring the capped area to the design grade for caps as discussed in Section 4.5.5. The excavations are backfilled with borrow materials and revegetated with native grasses. This alternative is based on the selection of Alternative 6f for Basin A.

4.6.19 <u>Alternative 8: Direct Soil Washing (Solvent Washing); Direct Solidification/Stabilization (Cement-Based Solidification)</u>

Alternative 8 is a treatment alternative that is applicable to the Basin A Medium Group. The major components of Alternative 8 are the following:

- Excavation of soils exceeding the Human Health SEC
- Screening and size reduction of the soils
- Separation of remaining oversized materials and debris followed by disposal of oversized material in an on-post landfill

- Treatment of organics in excavated soils through direct solvent washing
- Off-post treatment and disposal of the organic effluent from solvent washing
- Treatment of inorganic exceedances in excavated soils through direct cement-based solidification
- Backfill of treated soils from solvent washing and solidification
- Monitoring to observe durability of the solidified soil

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Description Volume, is used to excavate soils. During excavation operations, dust is suppressed and

emissions of volatiles and odors are controlled. Dewatering is required for the Basin A Medium Group to allow the excavation of soils near the water table.

Excavated soils are screened to remove debris and oversized materials. The oversized material is fed to a size reduction unit as described in Section 7.3 of the Technology Description Volume, then back into the feed stream. The maximum size of the feed material is 1/2 inch in diameter. The feed is then mixed and agitated with refrigerated triethylamine (TEA) solvent and NaOH in a washer/dryer mixer vessel. As the solvent breaks the organics/water/solids bonds in the waste, the solids are released and settle to the bottom of the vessel. The solvent/water mixture is removed and decanted. Decanted TEA is sent to a striping column where the contaminants are separated from the TEA and the TEA is recycled to the washer/dryer mixing vessel. The water is sent to another stripping column to remove any residual TEA. The product water is later added back to the treated soils to return them to their pre-treatment moisture content. Several extractions are necessary to obtain the desired contaminant removal. Once contaminant removal is achieved, product materials are adjusted back to neutral pH and returned for use as backfill. The residual TEA containing the concentrated contaminants is sent off post for disposal.

Following solvent extraction, soils with inorganics above the Human Health SEC are solidified by adding cement at a ratio of 0.2 tons/ton of soil as discussed in Section 4.6.22. The solidified soils are backfilled on post, but solidification results in a volume increase of nearly 40 percent. Four feet of thermally desorbed soils are placed over the solidified soils to prevent damage from freeze/thaw stresses. The durability of the solidified soils is monitored, and the cover is maintained by repairing any erosion damage. A layer of topsoil is placed over the backfilled material and revegetated with native grasses. Figure 4.6-1 provides a schematic of this treatment alternative.

4.6.20 Alternative 8a: Direct Soil Washing (Solvent Washing)

Alternative 8a is a treatment alternative that is applicable to the Basin F Wastepile and Sewer Systems Medium Groups. It differs from Alternative 8 in that these subgroups do not require

solidification of inorganic exceedances. The major components of Alternative 8a are the following:

- Excavation of soils exceeding the Human Health SEC
- Screening and size reduction of the soils
- Separation of remaining oversize materials and debris followed by disposal of oversized material in an on-post landfill
- Treatment of organics in excavated soils through direct solvent washing
- Off-post treatment and disposal of the organic effluent from solvent washing
- Backfilling of treated soils

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Description Volume, is used to excavate soils. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Excavated soils are screened to remove debris and oversized materials. The oversized material is fed to a size reduction unit as described in Section 7.3 of the Technology Description Volume, then back into the feed stream. The maximum size of the feed material is 1/2 inch in diameter. The feed is then mixed and agitated with refrigerated TEA solvent and NaOH in a washer/dryer mixer vessel. As the solvent breaks the organics/water/solids bonds in the waste, the solids are released and settle to the bottom of the vessel. The solvent/water mixture is removed and decanted. Decanted TEA is sent to a stripping column where the contaminants are separated from the TEA and the TEA is recycled to the washer/dryer mixing vessel. The water is sent to another stripping column to remove any residual TEA. The product water is later added back to the treated soils to return them to their pre-treatment moisture content. Several extractions are necessary to obtain the desired contaminant removal. Once contaminant removal is achieved, product materials are adjusted back to neutral pH and returned for use as backfill. The residual TEA containing the concentrated contaminants is sent for off-site disposal. Following treatment, the treated soil is backfilled and covered with a layer of topsoil. The area is subsequently revegetated with native grasses. Figure 4.6-2 provides a schematic of the solvent washing process.

4.6.21 Alternative 9a: Direct Soil Washing (Solution Washing); Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification)

Alternative 9a is a treatment alternative developed for the Basin F Wastepile Medium Group. This alternative involves the removal of OCPs and salts through direct soil washing. The remaining organics in the washed soils are destroyed by direct thermal desorption. The treated soils are then backfilled. The major components of Alternative 9a are the following:

- Excavation of soils exceeding the Human Health SEC
- Separation of oversize soils and any debris as a pre-treatment step followed by disposal of oversized material in an on-post landfill
- Treatment of excavated soils to reduce OCPs and remove salts using solution washing
- Treatment of soil washing effluent with a bioreactor attached to the soil washer as a post-treatment step
- Treatment of residual organics by direct thermal desorption
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment
- Backfill of treated soils from soil washing and thermal desorption

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Description Volume, is used to excavate soils exceeding the Human Health SEC. During excavation operations, dust is suppressed and volatile and odor emissions are controlled.

Soil washing is a direct physical/chemical treatment process that removes organic compounds using washing solutions consisting of water and additives, such as surfactants, that increase the removal efficiency of the washing processes. The soil washing process is designed primarily as a pre-treatment or partial treatment technology, and is used in conjunction with other treatment technologies (i.e., thermal desorption) to provide overall soil remediation. As discussed in Section 12.1 of the Technology Description Volume, soil washing treatability studies for RMA indicate that OCPs are not effectively removed from either the coarse- or fine-grained soil

fractions. Therefore the soils that contain residual OCP contamination require further treatment through thermal desorption.

Figure 4.6-3 provides a schematic of the soil washing process. Excavated soils are screened to remove debris and oversized materials and mixed with the soil washing solution to form a slurry. The slurry is subjected to a series of intense scrubbing processes to free contaminated fine particles from sand and gravel particles. The slurry is then subjected to physical classification steps to separate the washed soils and the process water. The washed soil is then backfilled if the residual levels of contaminants are below the SEC. The washed soil is subjected to subsequent treatment if the levels of residual contaminants are above the SEC. The process water is treated to remove contaminants and recirculated back into the soil washing process as discussed in Section 12.1 of the Technology Description Volume.

The soils with residual levels of OCPs are processed through the thermal desorber at 300°C at a rate of approximately 340 BCY/day with a 70 percent online factor since the soils feed is saturated following soil washing. Section 4.6.23 presents a discussion of the centralized thermal desorption facility. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post landfill. Treated soils are then backfilled. Since thermal desorption removes the organic content of soils during processing, a layer of topsoil is placed over the backfilled soils and is revegetated with native grasses.

4.6.22 Alternative 10: Direct Solidification/Stabilization (Cement-Based Solidification)

Alternative 10 is a treatment alternative that is applicable to the Buried M-1 Pits and Burial Trenches Subgroups. The major components of Alternative 10 are the following:

- Excavation of soils exceeding the Human Health SEC
- Separation of oversize soils and any debris as a pre-treatment step followed by disposal of oversized material in an on-post landfill

- Treatment of excavated soils by direct cement-based solidification and backfill of the solidified soil along with the installation of additional soil cover
- Monitoring to observe durability of the solidified soil

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Description Volume, is used to excavate soils exceeding the Human Health SEC. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled.

The solidification process starts by mixing the contaminated soil with Portland cement as discussed in Section 10.1 of the Technology Description Volume. A variety of aluminum silicate compounds form during the hydration process and bind the soil particles and contaminants into the crystalline lattice of the cement matrix. Figure 4.6-4 is a schematic of direct solidification. The final product varies from a granular, soil-like material to a cohesive solid, depending on the amount of binder added and the contaminants present in the soil. As hydration proceeds and the crystallinity of the matrix increases, the porosity and internal surface area decrease. The final product is much less permeable than the contaminated soil, and the contaminants are physically incorporated and sometimes chemically bonded to the cement matrix. The overall effect is to inhibit the leaching of contaminants from the solidified/stabilized mass.

Solidification requires equipment for chemical storage, materials handling, materials mixing, and materials control. Dry binder ingredients, such as Portland cement, fly ash, and lime, are usually delivered in bulk transport trailers and stored in elevated metal storage silos. Liquid ingredients, such as hydrated lime and soluble silicates, are delivered in both bulk and drummed shipments and are stored in tanks or buildings. Storage tanks and buildings may require protection from extreme heat or cold for year-round operations.

The determination of binder ratios and additive levels is site- and soil-specific. As discussed in Section 10.1 of the Technology Description Volume, preliminary results from the treatability studies conducted by the U.S. Army Corps of Engineers Waterways Experimental Station (WES)

indicate that a binder-to-soil ratio of 0.2 tons/ton of soil (weight basis) is generally optimum for RMA soils. A volume increase usually accompanies the solidification process. In most cases of cement-based solidification, the volume of the final mixture is nearly 40 percent greater than the original in-place volume of the contaminated soil.

In general, solidified soils are backfilled in the original excavation and a soil cover provides weather protection for the treated material. In some cases, the configuration of the site or depth of the excavation precludes backfilling all of the processed material. These excess soils are placed in the on-post landfill. In this case, the solidified materials are placed in forms and allowed to cure for a few days, and then removed and the "monoliths" placed in the landfill.

4.6.23 Alternative 13: Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification)

Alternative 13 is a treatment alternative that is applicable to the Basin A Medium Group and the South Plants Central Processing and South Plants Balance of Areas Subgroups. The major components of Alternative 13 are the following:

- Excavation of soils exceeding the Human Health SEC
- Separation of oversize soils and any debris as a pre-treatment step followed by disposal of oversized material in an on-post landfill
- Treatment of organics in excavated soils through direct thermal desorption
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment
- Treatment of inorganic exceedances in excavated soils through direct cement-based solidification
- Backfill of treated soils from thermal desorption and solidification
- Monitoring to observe durability of the solidified soil

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Description Volume, is used to excavate soils. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Dewatering is required for the Basin A Medium Group to allow the excavation of soils near the water table.

For direct thermal desorption, the soils are transported to the centralized thermal desorber where they are prepared as feedstock for the thermal desorber. Typically, large objects (greater than 1.5 to 2.0 inches) are screened from the feedstock and disposed in the on-post landfill. The centralized thermal desorption facility requires two direct-fired, inclined rotary dryers (52 ft long and 10 ft in diameter) operating under induced draft at 300°C as discussed in Section 7.1 of the Technology Description Volume. The total soil processing rate at 20 percent moisture is 1,300 BCY/day with an overall soil residence time of 50 minutes. The processing rates varies to 2,000 BCY/day with a 65 percent online factor to based on a 10 percent moisture content of the solids feed. Figure 4.6-5 presents a schematic of this alternative.

As described in Section 7.1 of the Technology Description Volume, off gas from the desorber passes through a cyclone separator before entering the secondary combustion chamber (SCC). The particulates removed by the cyclone are recombined with the treated soil or are treated separately to immobilize the metals. Organic contaminants in the cyclone off gas are destroyed in the SCC at an operating temperature of 1,200°C and a residence time of 2.5 seconds. Off-gas treatment involves the removal of the acid gases formed in the SCC oxidation reactions and the particulates carried over from the cyclone separator. Other off-gas system equipment consists of a spray tower for adiabatic gas cooling and a baghouse for particulate removal. A caustic quench step is added to remove acid gases.

Soils with inorganics above the Human Health SEC are solidified by adding cement at a ratio of 0.2 tons/ton of soil as discussed in Section 4.6.22. The solidified soils are backfilled on post, but solidification results in a volume increase of nearly 40 percent. Four feet of

thermally desorbed soils are placed over the solidified soils to prevent damage from freeze/thaw stresses. The durability of the solidified soils is monitored, and the cover is maintained by repairing any erosion damage. A layer of topsoil is placed over the backfilled material and revegetated with native grasses.

4.6.24 Alternative 13a: Direct Thermal Desorption (Direct Heating)

Alternative 13a is a treatment alternative that is applicable to the Basin F Wastepile, Secondary Basins, Buried Sediments/Ditches and Sewer Systems Medium Groups and the Section 36 Lime Basins, South Plants Ditches, South Plants Tank Farm, and Section 36 Balance of Areas Subgroups. It differs from Alternative 13 in that these medium groups and subgroups do not require solidification of inorganic exceedances. The major components of Alternative 13a are the following:

- Excavation of soils exceeding the Human Health SEC
- Separation of oversize soils and any debris as a pre-treatment step followed by disposal of oversized material in an on-post landfill
- Treatment of organics in excavated soils through direct thermal desorption
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment
- Backfilling of treated soils

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Description Volume, is used to excavate soils. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Dewatering is required for the Section 36 Lime Basins and Balance of Areas Subgroups to allow the excavation of soils near the water table. Direct thermal desorption volatilizes organic contaminants from excavated soils and subsequently destroys the volatilized organics in a combustion chamber. Figure 4.6-6 is a schematic of this alternative. The centralized facility operates at 300°C as

discussed in Section 4.6-23. The solids processing rate varies from 1,300 to 2,000 BCY/day with a 65 percent online factor based on the moisture content of the soil.

Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post landfill. Treated soils are backfilled. Since thermal desorption removes the organic content of soils during processing, a layer of topsoil is placed over the backfilled soils and is revegetated with native grasses.

4.6.25 Alternative 13b: Direct Thermal Desorption (Direct Heating); Landfill (On-Post Landfill)

Alternative 13b is a treatment alternative that is applicable to the Sanitary Landfills Medium Group. This alternative was developed specifically for this medium group because the debris from the site cannot be effectively solidified to address inorganic exceedances; therefore, it must be landfilled to control potential contaminant migration. The major components of Alternative 13b are the following:

- Excavation of soils exceeding the Human Health SEC
- Separation of oversize soils and any debris as a pre-treatment step followed by disposal of oversized material in an on-post landfill
- Treatment of organics in excavated soils through direct thermal desorption
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment
- Disposal of treated soils and debris in the on-post landfill
- Backfill of sites with borrow material

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Description Volume, is used to excavate soils. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled.

The direct thermal desorption equipment operates at a temperature of 300°C and a throughput of 1,300 to 2,000 BCY/day with a 65 percent online factor depending on the moisture content of the solids feed. All of the treated soils, including the particulates collected from the emission control equipment, are placed in the on-post landfill.

Excavated soils from the Sanitary Landfills Medium Group that contain inorganic exceedances are not treated by direct solidification/stabilization because the large amounts of debris present in these soils would necessitate intensive pre-treatment and materials separation prior to solidification/stabilization. Therefore, these materials are placed directly into an on-post landfill, as discussed in Section 4.6.6, following thermal treatment.

4.6.26 Alternative 14: Incineration/Pyrolysis (Rotary Kiln): Landfill (On-Post Landfill)

Alternative 14 is a treatment alternative that is applicable to the Disposal Trenches Medium Group. The major components of Alternative 14 are the following:

- Excavation of soils and debris from disposal trenches
- Separation of any oversize debris as a pre-treatment step followed by disposal of oversized debris in an on-post landfill
- Treatment of organics in excavated soils through rotary kiln incineration
- Placement of treated soils as well as particulates and salts from the scrubber blowdown in the on-post landfill and backfill of excavations with borrow materials
- Long-term O&M of the on-post landfill including cap maintenance, leachate treatment, and groundwater monitoring

Specialized earth-moving equipment, as described in Section 4.1 of the Technology Description Volume, is used to excavate soils. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. The disposal trenches are excavated inside a vapor enclosure to control vapors as described in detail in Section 4.1 of the Technology Description Volume. The vapor enclosure includes emission control

equipment to prevent the buildup of toxic gases inside the enclosure. Dewatering is required to allow the excavation of soils near the water table.

The soils and debris are first excavated using specialized equipment and moved to the central processing area where they are prepared as feedstock. Typically, objects larger than 1.5 to 2.0 inches are screened from the feedstock and rejected as oversize. Debris is sized so that it is no larger than 1 ft by 1 ft, and all rebar is removed from concrete. Oversize and separated debris is landfilled.

The incinerator is a direct-fired, inclined rotary kiln operating under induced draft at a discharge temperature of 760°C. Because the soil discharges from the incinerator at a higher temperature than it would from a thermal desorber (300°C), fuel requirements for incineration are higher per ton of soil processed. The resulting higher volume of flue gas forces an increase in the diameter of the rotary kiln incinerator in order to maintain the same design space velocity, and it also forces an increase in the sizing of the off-gas treatment system for the same soil processing rate. The overall soil residence time is 66 minutes. Figure 4.6-7 presents a schematic of rotary kiln incineration for Alternative 14.

As with thermal desorption, off gas from the incinerator passes through a cyclone separator before entering the SCC. Residual organic contaminants in the cyclone off gas are destroyed in the SCC at an operating temperature of 1,200°C and a residence time of 2.5 seconds. As discussed in Section 7.2 of the Technology Description Volume, the off-gas treatment sequence following the SCC employs a spray tower for adiabatic gas cooling, a baghouse for particulate removal, and a venturi scrubber for additional particulate removal. A caustic quench step is added to remove acid gases.

Incineration causes generation of an ash. Natural organic material is burned out of the soil matrix. The clay and silt fractions tend to disappear as the smaller particles form sand-sized aggregates. The pH of the soils increases with the loss of hydroxyl groups from the clay

minerals and the conversion of carbonate minerals to their oxide forms. Since metal oxides tend to be more soluble than the carbonates, incineration tends to increase the extractability of metal constituents in treated soil over the extractability of metals in untreated soil.

Excavated soils from the subgroups in this medium group that contain inorganic exceedances are not treated by direct solidification/stabilization following rotary kiln incineration because the large amounts of debris present in these soils would necessitate intensive pre-treatment and materials separation prior to solidification/stabilization. Therefore, these materials are placed directly into an on-post landfill following thermal treatment.

4.6.27 Alternative 16a: In Situ Physical/Chemical Treatment (Vacuum Extraction)

Alternative 16a is a treatment alternative that removes volatile organic contaminants using in situ vacuum extraction (SVE). It is only applicable to the South Plants Tank Farm Subgroup. The major components of Alternative 16a are the following:

- Treatment of soils to remove volatile organics above the Human Health SEC through SVE

- Monitoring during treatment to document contaminant reduction

Vacuum extraction is a treatment technology designed to physically remove VOCs in situ by passing air through the sub-surface pore spaces. As discussed in Section 12.3 of the Technology Description Volume, SVE systems are designed to maximize air flow through the zone of contamination, thereby recovering organic-laden vapors. The system operates by applying a vacuum to extraction points in the subsurface, resulting in air flow through the pore spaces between soil particles to the extraction points. The technology is generally used to remove VOCs from vadose-zone soils. However, if the extraction points are located directly above the water table, the vacuum extraction system may also recover dissolved or free-phase VOCs at the top of the water table.

The induced air flow through the soil pore spaces between the soil particles entrains contaminated vapors and water to the extraction points. From the extraction points, the air stream flows through a piping system to a vapor/liquid separator. The vapor/liquid separator removes the entrained water and stores it for subsequent treatment. The contaminated vapors are transferred to vapor treatment.

Extraction points are typically vertical wells designed with a vacuum-tight seal near the surface and an extraction zone (e.g., screen) corresponding to the profile of subsurface contamination. A well consists of slotted PVC pipe placed in a borehole surrounded by a permeable sand pack. Positive-displacement blowers, centrifugal blowers, or vacuum pumps are used to create the vacuum that draws ambient air through the soil, stripping and volatilizing contaminants from the soil matrix into the air stream. Blowers ranging from 100 to 6,000 cubic feet per minute (CFM) have been used, and vacuums of 1 to 8 inches of mercury are typical. Individual blowers are selected on a site-specific basis based on the design air flow rate through the soil.

The condensed moisture from the air stream is treated by transferring the liquid to the CERCLA Wastewater Treatment Plant. Construction of separate facilities is not cost effective because of the small size of this waste stream. The extracted vapors are treated by granular activated carbon (GAC) and discharged to the atmosphere.

4.6.28 Alternative 17: In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)

Alternative 17 is a treatment alternative that was developed for the Basin A Medium Group. Surficial soils containing organics (primarily OCPs) exceeding Human Health SEC are first treated using surface soil heating. In situ soil flushing is then used to remove other exceedance contaminants in both surficial and subsurface soils within the exceedance volume. The major components of Alternative 17 are the following:

- Treatment of organic contaminants in surficial soils above the Human Health SEC through in situ surface soil heating

- Treatment of inorganic and organic contaminants in subsurface and surficial soils through in situ physical/chemical treatment

- Monitoring during treatment to document contaminant reduction and potential migration of contaminants

Surface soil heating thermally desorbs organic contaminants at soil temperatures of 250°C using a radiant heat source applied at the surface. The desorbed organic vapors are then collected at the surface and drawn into an off-gas treatment system as described in Section 4.5.9.

As discussed in Section 12.2 of the Technology Description Volume, soil flushing is an in situ treatment technology designed to remove contaminants from soils by passing extractant solutions through the soils. The process involves the creation of an active leaching field in areas of soil contamination to accelerate percolation and leaching of contaminants from the soil. As the flushing solution percolates through the treatment zone, it mobilizes contaminants from the soil matrix. The flushing solution then carries the mobilized contaminants through the soil profile until it mixes with the underlying groundwater. The flushing solution and contaminants are collected in downgradient recovery wells or trenches and pumped to a treatment system. Following treatment, the captured groundwater is discharged to the leaching field, forming a closed-loop recovery system.

Surfactants improve the ability of an aqueous flushing solution to mobilize strongly adsorbed, low-solubility compounds. However, interactions between surfactants, soil media, contaminants, and microbial populations can lead to problems caused by loss of permeability resulting from enhanced microbial growth or expansion of clays. Surfactants may be lost within the soil or groundwater environment through adsorption on solid surfaces, absorption by partitioning into free-phase contaminants, and biodegradation. Complete removal of surfactants from the environment may not be possible, and surfactant recovery from the waste stream can be difficult.

In this alternative, the flushing solution is ponded over the soil area to be treated. As the flushing solution percolates through the treatment zone, it mobilizes contaminants from the soil matrix and carries the mobilized contaminants through the soil profile to the water table. The solution and contaminants are then collected in downgradient recovery wells at the Basin A Neck IRA and pumped to the Basin A Neck groundwater treatment system. The Basin A Neck IRA recovery and treatment systems require expansion if this alternative is selected. Costs to expand the system are included in the estimated costs for this alternative. This alternative must be closely coordinated with groundwater remedial alternatives for the Basin A Plume Group.

4.6.29 Alternative 19: In Situ Thermal Treatment (Radio Frequency/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)

Alternative 19 is a treatment alternative that was developed for the Basin A Medium Group and the Buried M-1 Pits, South Plants Central Processing, and South Plants Balance of Areas Subgroups. This alternative removes organic contaminants using in situ Radio Frequency (RF)/microwave heating and solidifies inorganic contaminants using in situ cement-based solidification. The major components of Alternative 19 are the following:

- Treatment of soils exceeding the Human Health SEC for organic contaminants through in situ RF/microwave heating
- Treatment of organic contaminants in off gases from the in situ thermal treatment process through thermal incineration and of liquid sidestream at the thermal desorption facility
- Treatment of soils with inorganic exceedances through in situ cement-based solidification
- Monitoring following treatment to document contaminant reduction and to observe durability of the solidified soils

The RF/microwave heating process involves the desorption and collection of organic compounds through the placement of electrodes into a grid of boreholes as discussed in Section 8.2 of the Technology Description Volume. The organics in the soil material are

mobilized by vaporization or steam stripping, or are thermally decomposed. The mobilized contaminants are then collected at the surface in a hood and drawn into an off-gas treatment system. The process equipment includes a radio frequency generator, a vapor collection system, and a vapor treatment system. In general, the proposed full-scale module design treats a soil block that is 100 ft long by 48 ft wide and 10 ft deep (Technology Description Volume).

RF/microwave heating is implemented by inserting electrodes in the ground and heating the soil to volatilize organic contaminants. The depth of the electrodes defines the depth of soil to be treated. As the soil is heated, volatilized contaminants and steam are collected from the soil through perforated electrodes that serve as vacuum extraction vents. The vapor containment and collection system collects the subsurface vapors, steam, and volatilized constituents and transports them to the vapor treatment system. The off gases are treated by catalytic incineration. Depending upon the concentration of the organic contaminants in the collected gases entering the incinerator, additional fuel may have to be added to the incinerator. The vent gases are scrubbed to remove hydrochloric acid formed during incineration and then quenched.

Post-treatment of the soil after RF/microwave heating is required. Due to the heating of the soil matrix, revegetation is necessary to restore the site to its original condition. The soil organic content has to be supplemented with fertilizers and native humic material to effectively maintain a vegetative cover.

Soils with inorganic exceedances of Human Health SEC are treated by in situ cement-based solidification. The major difference between direct and in situ solidification is the absence of the excavation and backfill steps required by direct processes. The mixing equipment is based on powerful drilling rigs rather than cement batch plants, which are available from specialty foundation and cut-off wall construction vendors. Instead of the soil being brought to the mixer, the mixing equipment is moved through the volume of soil to be remediated.

The equipment can drill as deep as 150 ft. Each type of specialized auger is supported by cement slurry storage and transfer equipment, and the binder ingredients are metered into the hollow-stem auger or kelly bar and injected into the soil column. The specialized auger is equipped with a shroud that can be used for vapor collection if volatile contaminants are expected. In situ cement-based solidification uses the same cement/soil ratio as direct cement-based solidification (Section 4.6.22), but consumes more binder because of the overlapping drilling pattern and the necessity of erring on the high side of the target formulation because of the difficulty in monitoring the in situ mixing.

In situ solidification results in a volume expansion of the treated soil. Based on the required binder ratio of 0.2 tons/ton of soil, the expansion may range between 10 and 25 percent. Post-treatment may involve recontouring the expanded soil in place, or removing the excess volume to Basin A or the on-post landfill.

4.6.30 Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating)

Alternative 19a is a treatment alternative developed for the Secondary Basins, Former Basin F, Section 36 Lime Basins, South Plants Tank Farm, Buried Sediments, and Section 36 Balance of Areas Subgroups. The major components of Alternative 19a are the following:

- Treatment of soil exceeding the Human Health SEC for organic contaminants through in situ RF/microwave heating

- Treatment of organic contaminants in off gases from the in situ thermal treatment process through catalytic incineration and of liquid sidestream at the thermal desorption facility

RF/microwave heating, as described in Section 4.6.29, treats organics exceeding the Human Health SEC. The soils are heated to 250°C, and vapors are collected and treated. This alternative removes organic contaminants using in situ heating and differs from Alternative 19 in that these subgroups do not require solidification/stabilization treatment for inorganic exceedances.

4.6.31 Alternative 19b: In Situ Thermal Treatment (RF/Microwave Heating,Surface Soil Heating)

Alternative 19b is a treatment alternative that has been developed for the Basin F Exterior Subgroup. This alternative differs from Alternatives 19 and 19a in that it addresses smaller volumes of deeper contamination using RF heating, and larger areas of shallow contamination using surface soil heating. The major components of Alternative 19b are the following:

- Treatment of subsurface soils exceeding the Human Health SEC for organic contaminants through in situ RF/microwave heating
- Treatment of remaining shallow soils exceeding Human Health SEC through surface soil heating
- Treatment of organic contaminant off gases from the in situ thermal treatment process through catalytic incineration and of liquid sidestream at the thermal desorption facility

Two in situ heating process options are included in this alternative. RF/microwave heating is used to treat organics in subsurface soils, and surface soil heating is used to address widespread surficial areas contaminated with organics. Both process options raise the temperature of the soil to 250°C. RF heating and surface soil heating are implemented as described in Section 4.6.29 and 4.5.9, respectively.

4.6.32 Alternative 20: In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification)

Alternative 20 is a treatment alternative was developed for the South Plants Balance of Areas Subgroups. In this alternative, OCPs in surficial soils are removed by in situ surface soil heating. Subsurface and surface soils with inorganic exceedances and subsurface soils with organic exceedances are excavated for further treatment. Soils exceeding Human Health SEC for organics are treated using thermal desorption and soils with inorganic exceedances are subsequently solidified. The major components of Alternative 20 are the following:

- Treatment of surficial soils with organic contamination exceeding the Human Health SEC through in situ surface soil heating

- Excavation of soils exceeding the Human Health SEC for inorganics in subsurface and surficial soils and for organics in subsurface soils

- Direct thermal treatment of excavated soils with organic exceedances

- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment

- Treatment of soils containing inorganic exceedances through direct cement-based solidification

- Backfilling of treated soils

- Monitoring through soil sampling and site reviews to observe durability of the solidified soil

Surface soil heating thermally desorbs organic contaminants from surficial soils by raising soil temperatures to 250°C as described in Section 4.5.9. Following in situ treatment of organics in surficial soils, soils with exceedances for organics in subsurface soils and inorganics in subsurface and surficial soils are excavated and treated by direct thermal desorption as discussed in Section 4.6-23. The thermal desorber operates at a temperature of 300°C and a processing rate of 2000 BCY/day based on the moisture content of the solids feed. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post landfill. Treated soils without inorganic exceedances of the principal threat criteria are backfilled. Since thermal desorption removes the organic content of soils during processing, a layer of topsoil is placed over the backfilled soils and is revegetated with native grasses.

Soils with inorganics above the Human Health SEC are solidified by adding cement at a ratio of 0.2 tons/ton of soil as discussed in Section 4.6.22. The solidified soils are backfilled on site. Four feet of thermally desorbed soils are placed over the solidified soils to prevent damage from freeze/thaw stresses. The durability of the solidified soils is monitored, and the cover is maintained by repairing any erosion damage.

4.6.33 Alternative 21: In Situ Thermal Treatment (In Situ Vitrification)

Alternative 21 is a treatment alternative specifically developed for the Buried M-1 Pits Subgroup since this process is only applicable to high levels of mixed organic and inorganic contamination and can only treat limited soil volumes. The major components of Alternative 21 are the following:

- Treatment of soils exceeding the Human Health SEC for organic and inorganic contaminants through in situ vitrification
- Treatment of organic and volatile inorganic contaminants contained in off gases from vitrification
- Monitoring through sampling and site reviews to observe durability of vitrified soil

As discussed in Section 8.3 of the Technology Description Volume, in situ vitrification uses electrical energy to melt soils and sludges for the purpose of thermochemically treating organic and immobilizing inorganic contaminants present within the treatment volume. Most in situ vitrification applications involve melting of natural soils; however, other naturally occurring or process residual chemicals may be treated. Organic and volatile inorganic contaminants that are not destroyed by the vitrification process are driven out of the soil, collected, and treated in a vapor treatment system. In situ vitrification equipment consists of the electrode array, power source, off-gas hood, and vapor treatment system. In situ vitrification is currently being developed by Geosafe Corporation. The technology has progressed through 90 tests and demonstrations from bench to pilot scale; six of the tests were conducted at full scale. However, in situ vitrification has not been used for commercial applications to date.

Geosafe has designed a full-scale system capable of treating an area with dimensions of 30 ft by 30 ft and a maximum depth of 30 ft. During operation, in situ vitrification is able to process 4 to 6 tons of soil per hour and requires 0.3 to 0.5 Kilowatts (kW) per pound of soil. The full-scale process takes place at temperatures ranging from 1,600°C to 2,000°C.

The processing area is covered by an octagonal-shaped off-gas collection hood that is 55 ft wide. Flow of air through the hood is controlled to maintain a lower pressure relative to atmospheric pressure. Since the process occurs at temperatures well above combustion minimums, an ample supply of air is provided to ensure excess oxygen is available for combustion of pyrolysis byproducts and organic vapors, if any exist. The off gases, combustion products, and air are drawn from the hood via an induced draft blower into the off-gas treatment system.

The off-gas treatment system includes quenching, pH-controlled scrubbing, demisting, heating (temperature and dew point control), particulate filtration, and GAC adsorption components. Section 8.3 of the Technology Description Volume discusses the off-gas control equipment for in situ vitrification.

Preparation of the treatment site is required. Groundwater in the soil treatment zone slows the vitrification process since the process requires that this water be vaporized prior to the melt progressing downward. Therefore, a sheet pile wall and dewatering wells may be installed to cut off groundwater flow into the area during in situ vitrification. Any vegetative growth and any surface debris is also cleared from the site. Site restoration activities include backfilling the disturbed area with clean soil, regrading the surface as necessary, removing the sheet piles, and revegetating the area with native grasses. A soil volume reduction of 28 percent is anticipated from in situ vitrification.

	Alternative Name[1]	Alternative Description
U1:	No Additional Action (Provisions of FFA)	Provisions of the FFA and the existing or planned IRAs; monitor potential migration.
U2:	Caps/Covers (Soil Cover)	Containment of potential UXO area; cover includes 4-ft soil cover and vegetation layers that control potential exposure and prevent damage to containment system; monitor effectiveness of system.
U3:	Detonation (On-Post Detonation) Incineration/Pyrolysis (Rotary Kiln Incineration)	Excavation of potential UXO identified by geophysical clearance; separation of UXO from excavated material; disposal of excavated materials/debris in on-post landfill; incineration of agent-filled UXO and detonation of HE-filled UXO.
U3a:	Detonation (On-Post Detonation)	Excavation of potential HE-filled UXO identified by geophysical clearance; separation of UXO from excavated material; disposal of excavated materials/debris in on-post landfill; detonation of HE-filled UXO.
U4:	Detonation (Off-Post Detonation); Incineration/Pyrolysis (Off-Post Incineration)	Excavation of potential UXO identified by geophysical clearance; separation of UXO from excavated material; disposal of excavated materials/debris in on-post landfill; preparation of UXO for transportation to an existing off-post Army facility; incineration of agent-filled UXO and detonation of HE-filled UXO at off-post Army incinerator.
U4a:	Detonation (Off-Post Army Facility)	Excavation of potential HE-filled UXO identified by geophysical clearance; separation of UXO from excavated material; disposal of excavated materials/debris in on-post landfill; preparation of UXO for transportation to an existing off-post Army facility; detonation of HE-filled UXO at off-post Army facility.
A1:	No Additional Action (Provisions of FFA)	Provisions of the FFA and the existing or planned IRAs; monitor natural attenuation/degradation and potential migration.
A2:	Caps/Covers (Soil Cover)	Containment of potential agent area; cover includes 4-ft soil cover and vegetation layers that control potential exposure and prevent damage to containment system; monitor effectiveness of system.
A3:	Soil Washing (Solution Washing); Landfill (On-Post Landfill)	Identification of soils containing agent; excavation of soils with agent; materials handling and sizing; soil washing with caustic; spray drying aqueous effluent; disposal of treated soils in on-post landfill.
A4:	Incineration/Pyrolysis (Rotary Kiln Incineration)	Identification of soils containing agent; excavation of soils with agent; materials handling and sizing; incineration of agent-contaminated soil; off-gas treatment of particulates and volatile inorganic contaminants; backfill of treated soils; disposal of particulates from off gas in on-post landfill.

[1] Small letters attached to alternative number indicate modifications to alternatives retained from the DSA.

	Alternative Name[1]	Alternative Description
A5:	Soil Washing (Solvent Washing) Landfill (On-Post Landfill)	Identification of soils containing agent; excavation of soils with agent; materials handling and sizing; solvent washing to degrade agent. Off-post treatment of aqueous effluent; disposal of treated soil in landfill.
B1:	No Additional Action (Provisions of FFA)	Provisions of the FFA and the existing or planned IRAs; monitor natural attenuation/degradation and potential migration.
B1a:	Caps/Covers (Clay/Soil Cap) with Consolidation; No Additional Action (Provisions of FFA)	Excavation of human health exceedances from inlets of lakes; consolidation of excavated soil in Basin A for containment; provisions of the FFA and the existing or planned IRAs for balance of area; monitor natural attenuation/degradation and potential migration for balance of area.
B2:	Biota Management (Exclusion, Habitat Modification)	Exclusion of biota through physical barriers and habitat modification; monitor natural attenuation/degradation and potential migration.
B3:	Landfill (On-Post Landfill)	Construction of on-post landfill; excavation of soil; transportation of soil to landfill; placement of soil in landfill; backfill of excavations with borrow soil; operation, maintenance, and monitoring of landfill.
B5:	Caps/Covers (Clay/Soil Cap)	Containment of biota exceedance area; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that limit potential wildlife exposure and prevent damage to containment system; monitor effectiveness of system.
B5a:	Caps/Covers (Clay/Soil Cap) with Consolidation	Consolidation of biota exceedance area with nearby area to be contained; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that limit potential exposure and prevent damage to containment system; backfill of excavations with borrow soil; monitor effectiveness of system.
B5b:	Caps/Covers (Clay/Soil Cap) with Modifications to Existing System	Installation of additional layers of cap/cover to augment existing cap from IRA; compacted low-permeability soil, biota barrier, and cover soil/vegetation layers modified to improve long-term performance of cap; monitor effectiveness of system.
B6:	Direct Thermal Desorption (Direct Heating)	Excavation of biota volumes; materials handling and sizing; direct thermal desorption of soil; off gas treatment of particulates and any volatile inorganic contaminants; backfill treated soil; disposal of particulates from off gas in on-post landfill.
B9:	In Situ Biological Treatment (Landfarm/Agricultural Practice)	Site clearing and preparation; treatment of biota exceedance area by landfarm/agricultural practice; monitor natural attenuation/degradation and potential migration.

[1] Small letters attached to alternative number indicate modifications to alternatives retained from the DSA.

Alternative Name[1]	Alternative Description
B10: Caps/Covers (Clay/Soil Cap) with Consolidation; In Situ Biological Treatment (Aerobic Biodegradation)	Excavation of human health exceedances from inlets of lakes; consolidation of excavated soil in Basin A for containment; in situ aerobic biodegradation of remaining balance of lake sediments through enhancing microbial degradation; monitor natural attenuation/degradation and potential migration of remaining balance of lake sediments.
B11: In Situ Thermal Treatment (Surface Soil Heating)	Site clearing and preparation; in situ surface soil heating of biota exceedance area; monitor natural attenuation/degradation and potential migration of low-level exceedances in subsurface soils; treatment of off gases from in situ heating.
B11a: In Situ Thermal Treatment (RF/Microwave Heating)	Site clearing and preparation; in situ RF/microwave heating of biota exceedance area; treatment of off gases from in situ heating.
B11b: In Situ Thermal Treatment (Surface Soil Heating, RF/Microwave Heating)	Site clearing and preparation; in situ surface soil heating and RF/microwave heating of biota exceedance area; treatment of off gases from in situ heating.
B12: Direct Soil Washing (Solvent Washing)	Excavation of biota exceedance volume; materials handling and sizing; direct solvent washing to remove contaminants. Off-post treatment of aqueous effluent; backfill of treated soil.
1: No Additional Action (Provisions of FFA)	Provisions of the FFA and the existing or planned IRAs; monitor natural attenuation/degradation and potential migration.
1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA)	Excavation and treatment of principal threat volume by direct thermal desorption (Alternative 13a); materials handling and sizing; disposal of oversized debris particulates in landfill; provisions of the FFA and the existing or planned IRAs for balance of area; monitor natural attenuation/degradation and potential migration for balance of area.
1b: Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; No Additional Action (Provisions of FFA)	Excavation of principal threat volume and treatment of organic exceedances by direct thermal desorption (Alternative 13a) and treatment of inorganic exceedances by direct solidification/ stabilization (Alternative 10); materials handling and sizing; disposal of oversized materials and particulates in landfill; backfill of solidified soil and placement of 4-ft cover; provisions of FFA and the existing or planned IRAs; monitor natural attenuation/degradation and potential migration for remaining balance of area.
2: Access Restrictions (Modifications to FFA)	Site access restrictions (fencing and modifications to FFA); monitor natural attenuation/degradation and potential migration

[1] Small letters attached to alternative number indicate modifications to alternatives retained from the DSA.

	Alternative Name[1]	Alternative Description
2a:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modifications to FFA)	Excavation and treatment of principal threat volume by direct thermal desorption (Alternative 13a); site access restrictions (fencing and modifications to FFA) for balance of area; materials handling and sizing; disposal of oversized materials and particulates in on-post landfill; monitor natural attenuation/degradation and potential migration for balance of area.
3:	Landfill (On-Post Landfill)	Construction of on-post landfill; excavation of human health exceedance volume soil; placement of soil in landfill; backfill of excavations with borrow soil; operation, maintenance, and monitoring of landfill.
3a:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill)	Excavation and treatment of principal threat volume by direct thermal desorption (Alternative 13a); construction of on-post landfill; excavation of remaining human health exceedance volume soil; placement of remaining soil in landfill; backfill of excavations with borrow soil; operation, maintenance, and monitoring of landfill.
5:	Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Walls)	Containment of human health exceedance area; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that control potential exposure and prevent damage to containment system; construct slurry wall; monitor effectiveness of system.
5a:	Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Walls) with Modifications to Existing System	Installation of additional compacted low-permeability soil, biota barrier, and soil cover/vegetation layers to augment existing cap and modifications to slurry wall from IRA; construction of slurry wall to augment existing system and improve long-term performance; monitor effectiveness of system.
5b:	Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Walls) with Consolidation	Consolidation of human health exceedances outside disposal trench areas as grading fill prior to containment of disposal trenches; cap/cover for trenches includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that control potential exposure and prevent damage to containment system; construct slurry wall around disposal trenches; monitor effectiveness of system.
6:	Caps/Covers (Clay/Soil Cap)	Containment of human health exceedance area; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that control potential exposure and prevent damage to containment system; monitor effectiveness of system.

[1] Small letters attached to alternative number indicate modifications to alternatives retained from the DSA.

	Alternative Name[1]	Alternative Description
6a:	Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap)	Excavation of principal threat volume and treatment of organic exceedances by direct thermal desorption (Alternative 13a) and inorganic exceedances by direct solidification/stabilization (Alternative 10); materials handling and sizing; disposal of oversized material and particulates in on-post landfill; backfill of solidified soils; containment of balance of exceedance area; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that limit potential exposure and prevent damage to containment system; monitor effectiveness of system for balance of site.
6b:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Consolidation	Excavation and treatment of principal threat volume by direct thermal desorption (Alternative 13); materials handling and sizing; disposal of oversized material and particulates in on-post landfill; consolidation of remainder of human health exceedances with nearby area to be contained; backfill of excavations with borrow soil; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that limit potential exposure and prevent damage to containment system; monitor effectiveness of system.
6c:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Modifications to Existing System	Excavation and treatment of principal threat volume by direct thermal desorption (Alternative 13a); materials handling and sizing; disposal of oversized material and particulates in on-post landfill; backfill of solidified soils; installation of additional layers of cap/cover to augment existing cap from IRA; compacted low-permeability soil, biota barrier, and cover soil/vegetation layers modified to improve long-term performance of cap; monitor effectiveness of system.
6d:	Caps/Covers (Clay/Soil Cap) with Modifications to Existing System	Containment of human health exceedance area; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layer to augment existing system and limit potential exposure; monitor effectiveness of system.
6e:	Caps/Covers (Composite Cap)	Containment of Basin F Wastepile; cap/cover includes compacted clay layer, flexible membrane liner, biota barrier, and cover soil/vegetative layers that improve long-term performance of wastepile; monitor effectiveness of system.

[1] Small letters attached to alternative number indicate modifications to alternatives retained from the DSA.

	Alternative Name[1]	Alternative Description
6f:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap)	Excavation and treatment of principal threat volume by direct thermal desorption (Alternative 13a); materials handling and sizing; disposal of oversized material and particulates in on-post landfill; containment of remaining human health exceedance area by cap/cover; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetative layers that limit potential exposure and prevent damage to containment system; monitor effectiveness of containment system for consolidated soils.
6g:	Caps/Covers (Clay/Soil Cap) with Consolidation	Consolidation of human health exceedance area with nearby area to be contained; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetative layers that limit potential exposure and prevent damage to containment system; backfill of excavations with borrow soil; monitor effectiveness of containment system for consolidated soils.
8:	Direct Soil Washing (Solvent Washing); Direct Solidification/ Stabilization (Cement-Based Solidification)	Excavation of human health exceedance volume; materials handling and sizing; direct solvent washing to treat organic volume; off-post treatment of concentrated organic contaminants; direct cement-based solidification of inorganic volume; backfill treated and solidified soils in excavations; monitor solidified soil.
8a:	Direct Soil Washing (Solvent Washing)	Excavation of human health exceedance volume; materials handling and sizing; direct solvent washing to treat organics; off-post treatment of concentrated organic contaminants; backfill of treated soil.
9a	Direct Soil Washing (Solution Washing); Direct Thermal Desorption (Direct Heating);	Excavation of human health exceedance volume; materials handling and sizing; direct soil washing to remove salts; treatment of aqueous effluent; direct thermal desorption of organics in fine- and coarse-grained fraction; treatment of particulates and volatile inorganic contaminants in off gas; treatment of off gases from in situ heating.
10:	Direct Solidification/ Stabilization (Cement-Based Solidification)	Excavation of human health exceedance volume; materials handling and sizing; direct cement-based solidification of soils; backfill solidified soils in excavations; landfill of oversized material and particultes; monitor solidified soil.
13:	Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	Excavation of human health exceedance volume; materials handling and sizing; direct thermal desorption of organic volume; treatment of particulates and volatile inorganic contaminants in off gas; disposal of particulates from off gas in on-post landfill; direct cement-based solidification of inorganic volume; backfill solidified soils in excavation; monitor solidified soil.

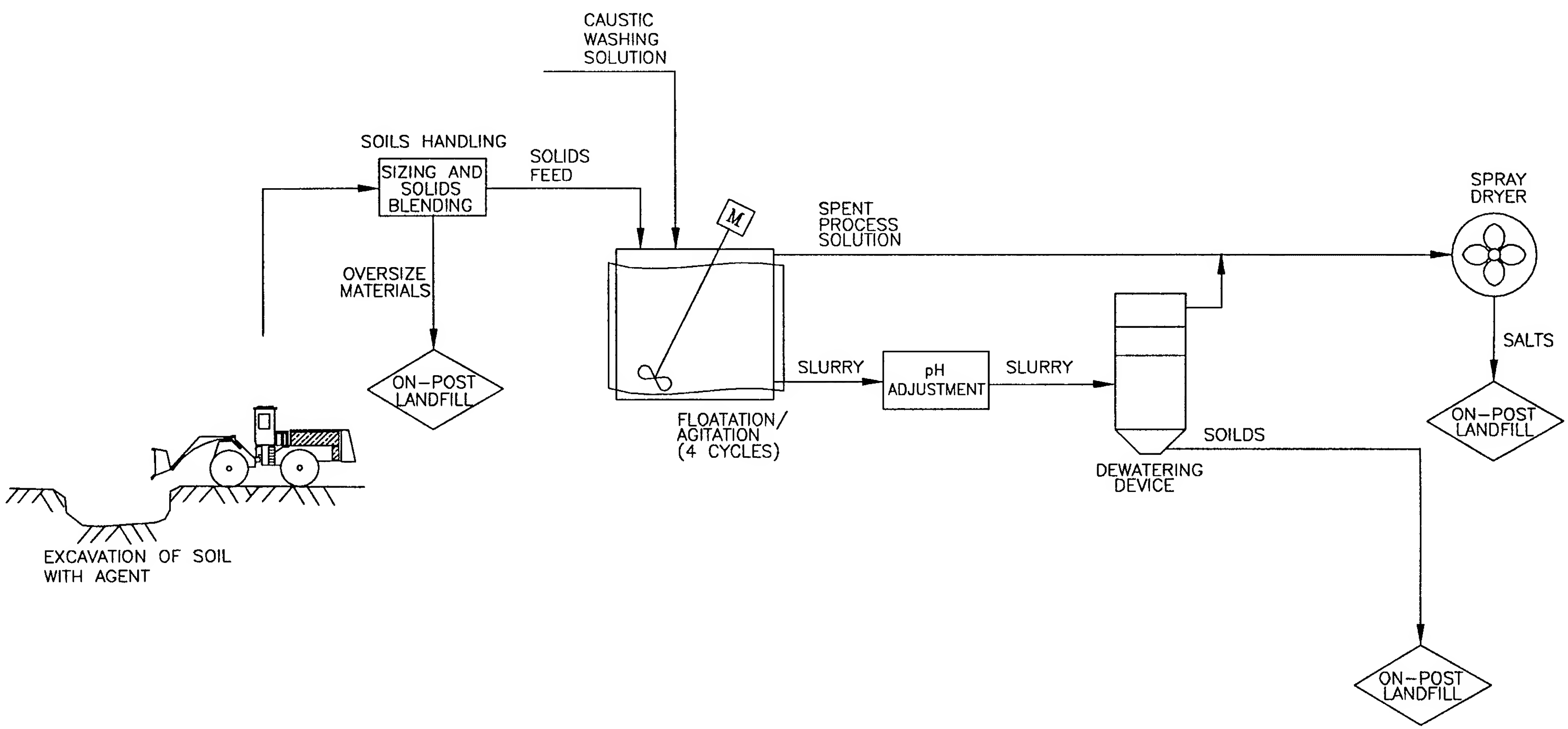
[1] Small letters attached to alternative number indicate modifications to alternatives retained from the DSA.

	Alternative Name[1]	Alternative Description
13a:	Direct Thermal Desorption (Direct Heating)	Excavation of human health exceedance volume; materials handling and sizing; direct thermal desorption of organic volume; treatment of particulates and volatile inorganic contaminants in off gas; disposal of particulates from off gas in on-post landfill.
13b:	Direct Thermal Desorption (Direct Heating); Landfill (On-Post Landfill)	Excavation of human health exceedance volume; materials handling and sizing; direct thermal desorption of organic volume; treatment of particulates and volatile inorganic contaminants in off gas; disposal of particulates from off gas and inorganic volume in on-post landfill; backfill of excavation with borrow soil.
14:	Incineration/Pyrolysis (Rotary Kiln); Landfill (On-Post Landfill)	Excavation of human health exceedance volume; materials handling and sizing; rotary kiln incineration of organic volume; treatment of particulates and volatile inorganic contaminants in off gas; disposal of treated material in on-post landfill; backfill of excavation with borrow soil.
16a:	In Situ Physical/Chemical Treatment (Vacuum Extraction)	Site clearing and preparation; in situ vacuum extraction of volatile organics in human health exceedance volume.
17:	In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)	Site clearing and preparation; in situ surface soil heating of organics in human health exceedance volume in surficial soil; treatment of off gases from in situ heating; in situ soil flushing of inorganics and organics in subsurface and surficial soils exceedance volume.
19:	In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	Site clearing and preparation; in situ RF/microwave heating of organics in human health exceedance volume; treatment of off gases from in situ heating; in situ cement-based solidification of inorganics in exceedance volume; monitor solidified soil.
19a:	In Situ Thermal Treatment (RF/Microwave Heating)	Site clearing and preparation; in situ RF/microwave heating of organics in human health exceedance volume; treatment of off gases from in situ heating.
19b:	In Situ Thermal Treatment (RF/Microwave Heating, Surface Soil Heating)	Site clearing and preparation; in situ surface soil heating and RF/microwave heating of organics in human health exceedance volume; treatment of off gases from in situ heating.
20:	In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	Site clearing and preparation; in situ surface soil heating of human health exceedance volume of organics in surficial soil; excavate remaining exceedance volume soils; direct thermal desorption of organics; treatment of particulates and volatile inorganic contaminants in off gas; disposal of particulates from off gas in on-post landfill; direct cement-based solidification of inorganics; backfill of solidified soil in excavation; monitor solidified soil.

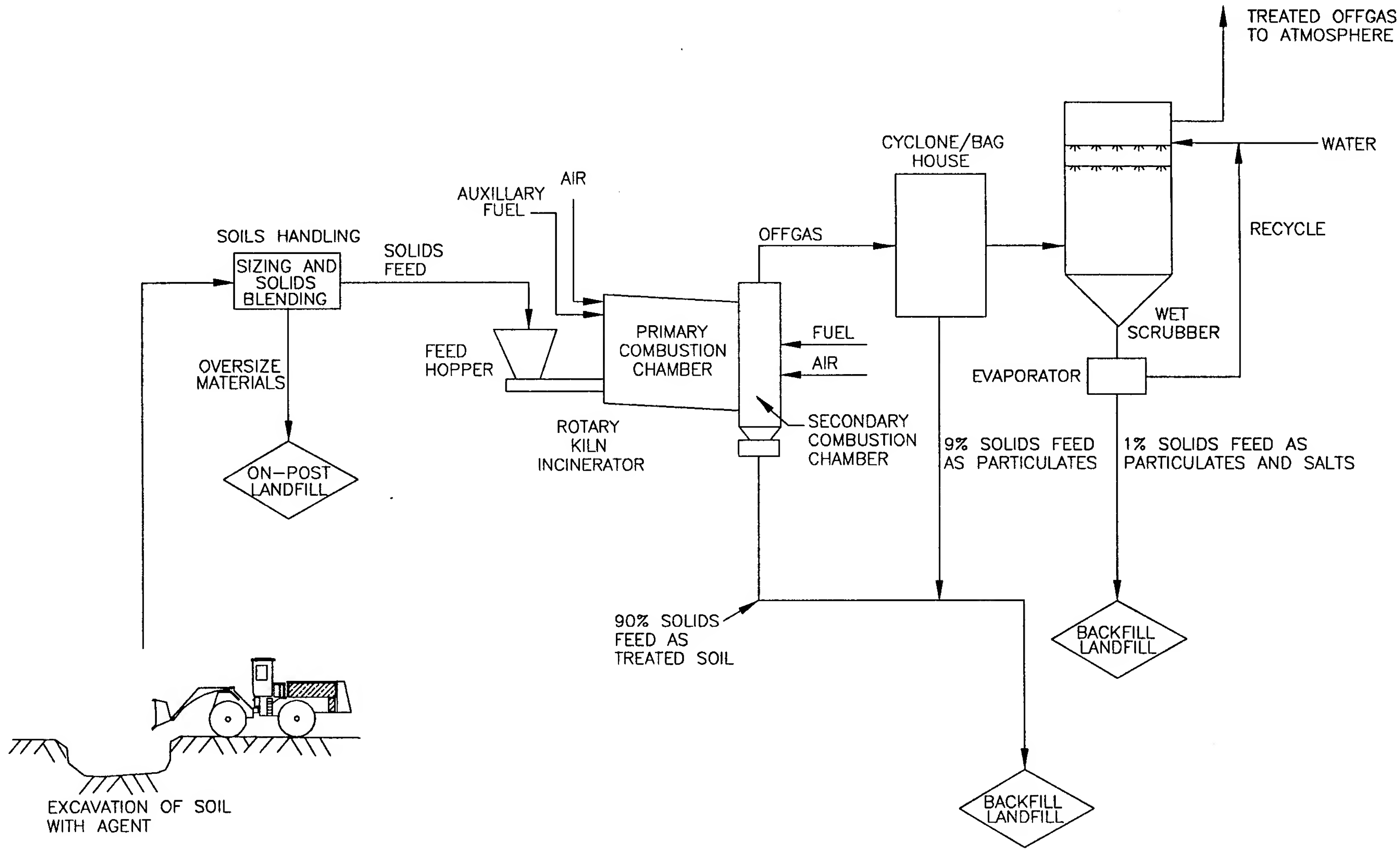
[1] Small letters attached to alternative number indicate modifications to alternatives retained from the DSA.

	Alternative Name[1]	Alternative Description
21:	In Situ Thermal Treatment (In Situ Vitrification)	Site clearing and preparation; in situ vitrification of human health exceedance volume organics and inorganics; treatment of off gases from in situ vitrification; backfill over vitrified materials to bring to grade.

[1] Small letters attached to alternative number indicate modifications to alternatives retained from the DSA.



Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.4-1 Alternative A3 Direct Soil Washing (Solution Washing); Landfill	Prepared by: Ebasco Services Incorporated



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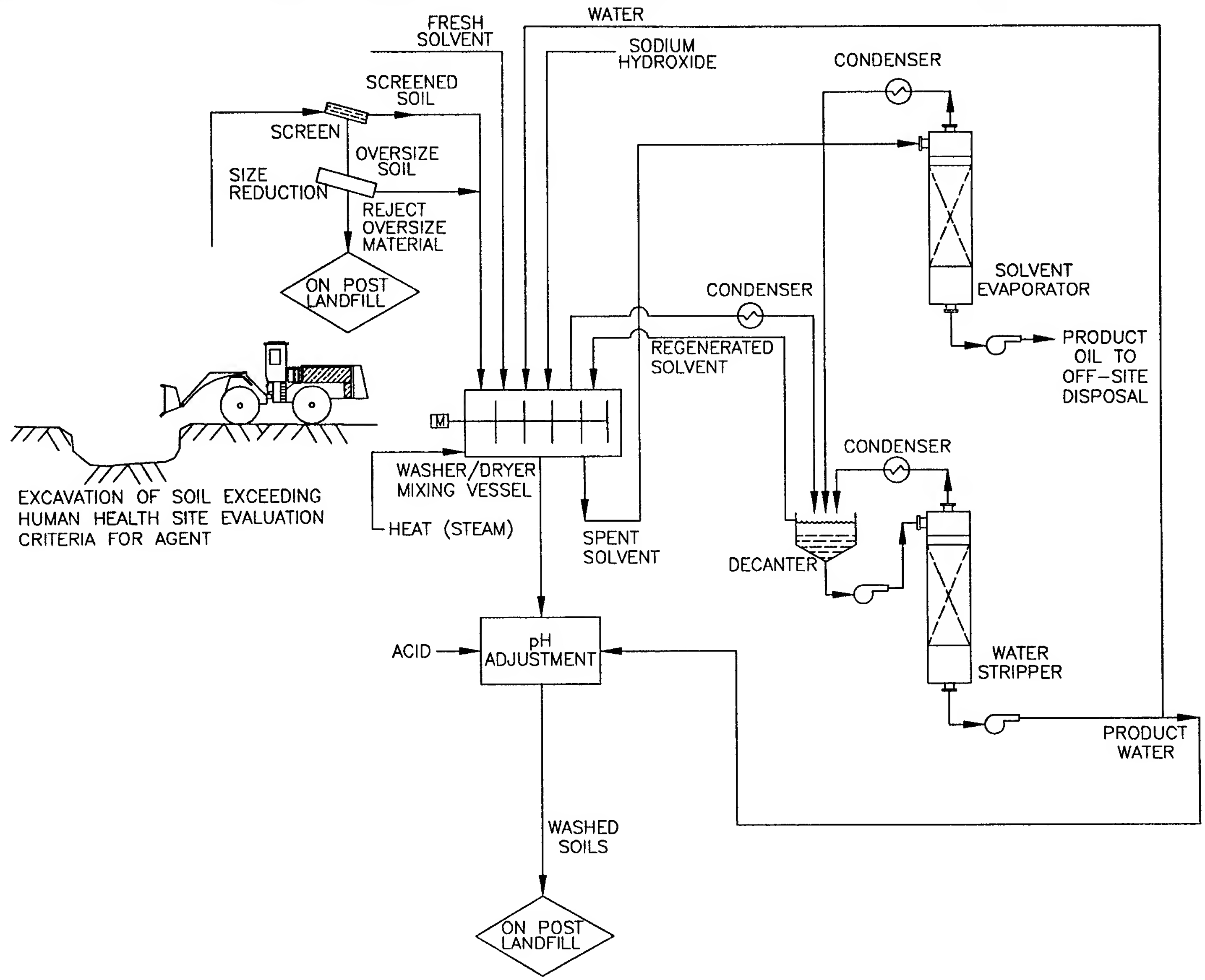
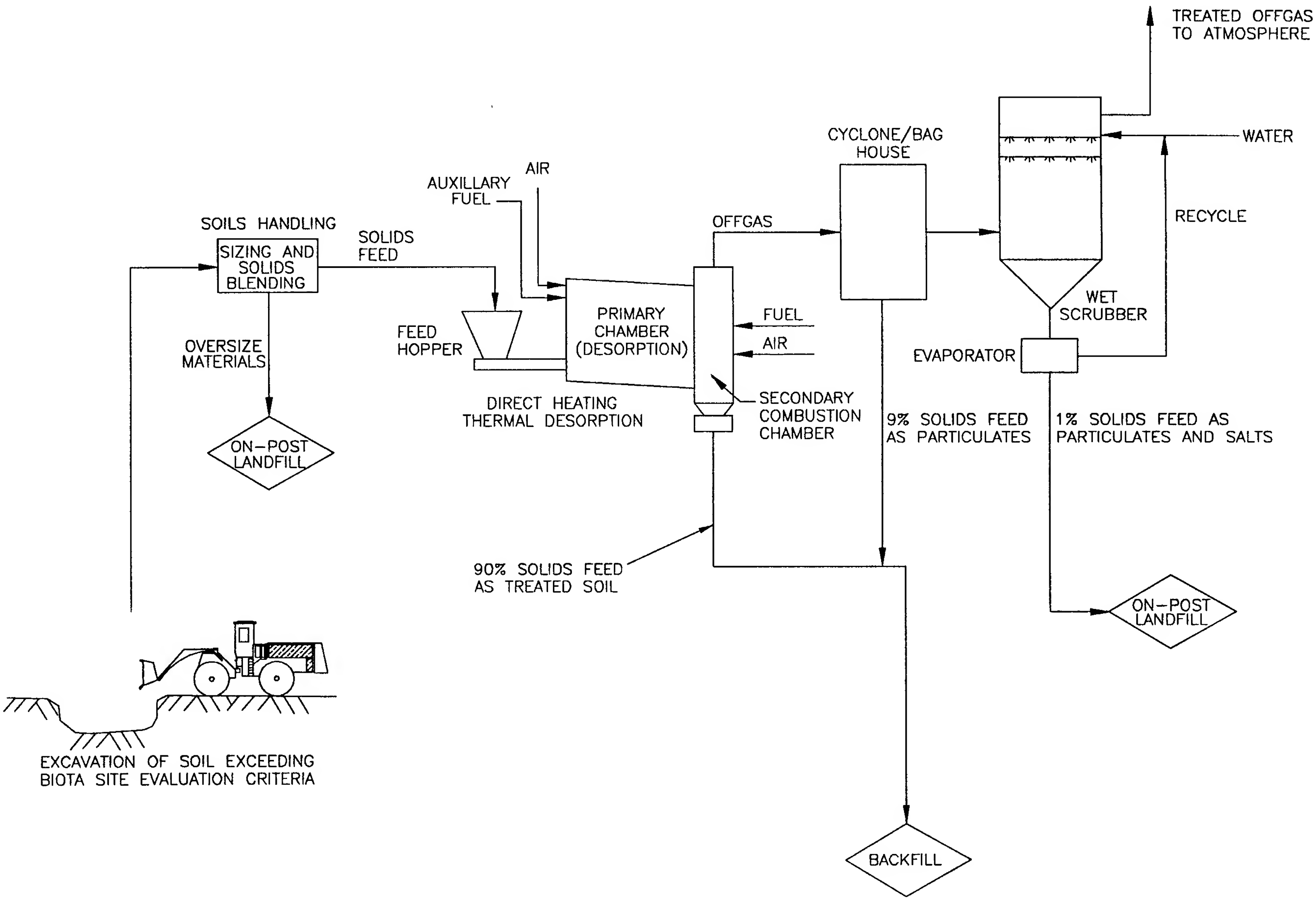
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 4.4-2
Alternative A4
Incineration/Pyrolysis

Prepared by:
Ebasco Services Incorporated

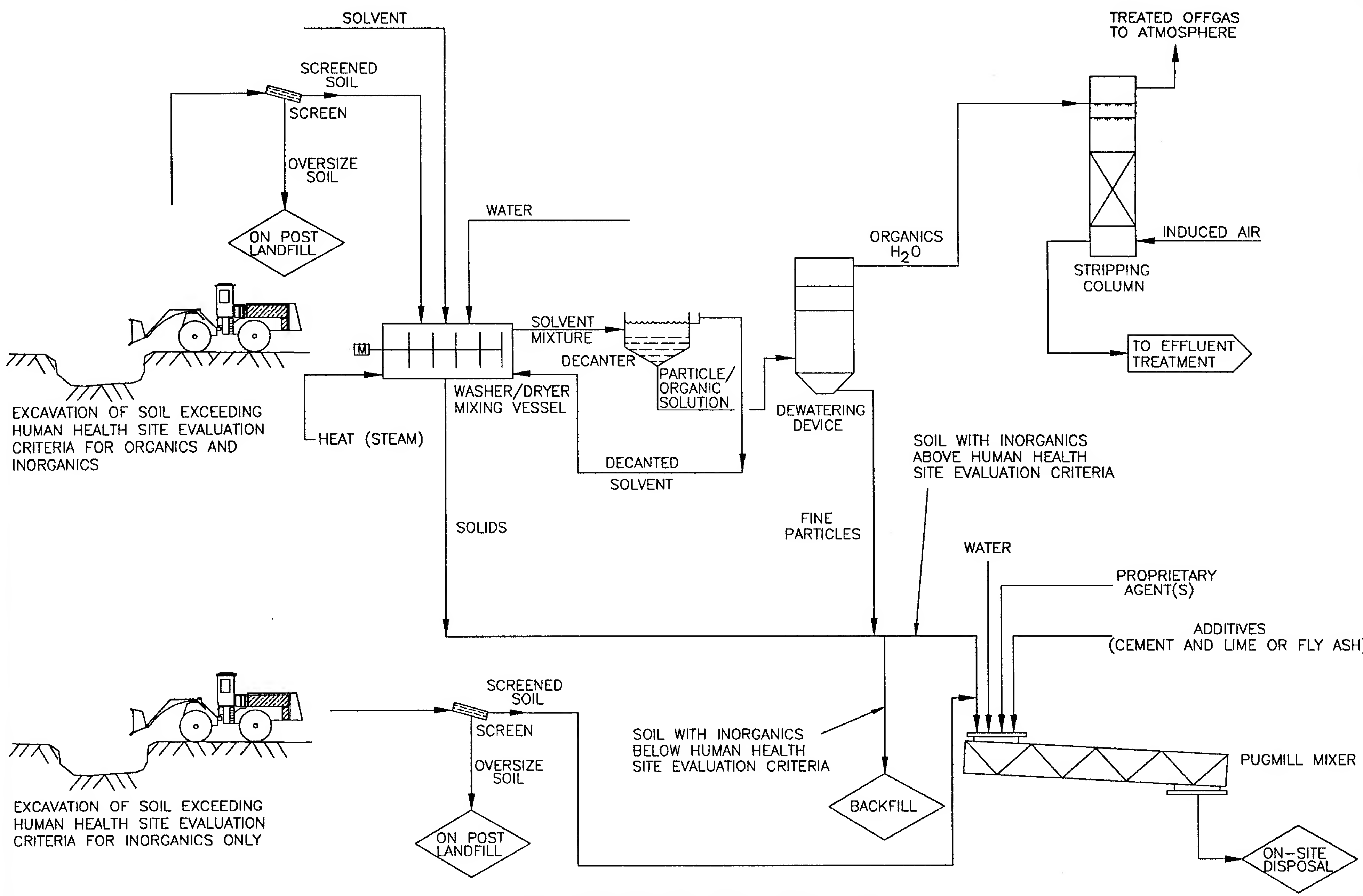


Prepared for: Office for the Program Manager for Rocky Mountain Arsenal	FIGURE 4.4-3 Alternative A5 Direct Soil Washing (Solvent Washing); Landfill	Prepared by: Ebasco Services Incorporated

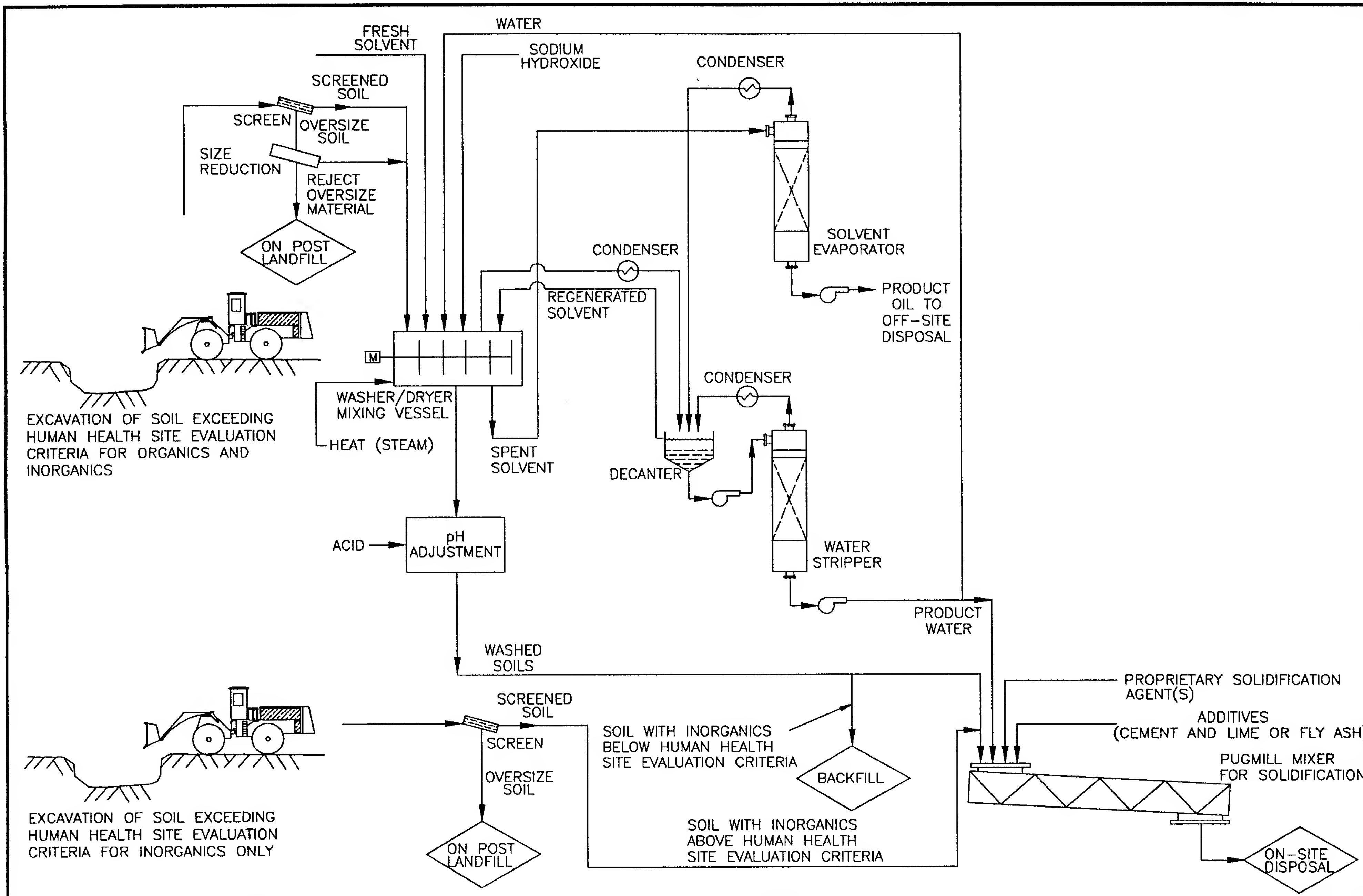


SOURCE: Figure 7.1-1, Technology Description Volume

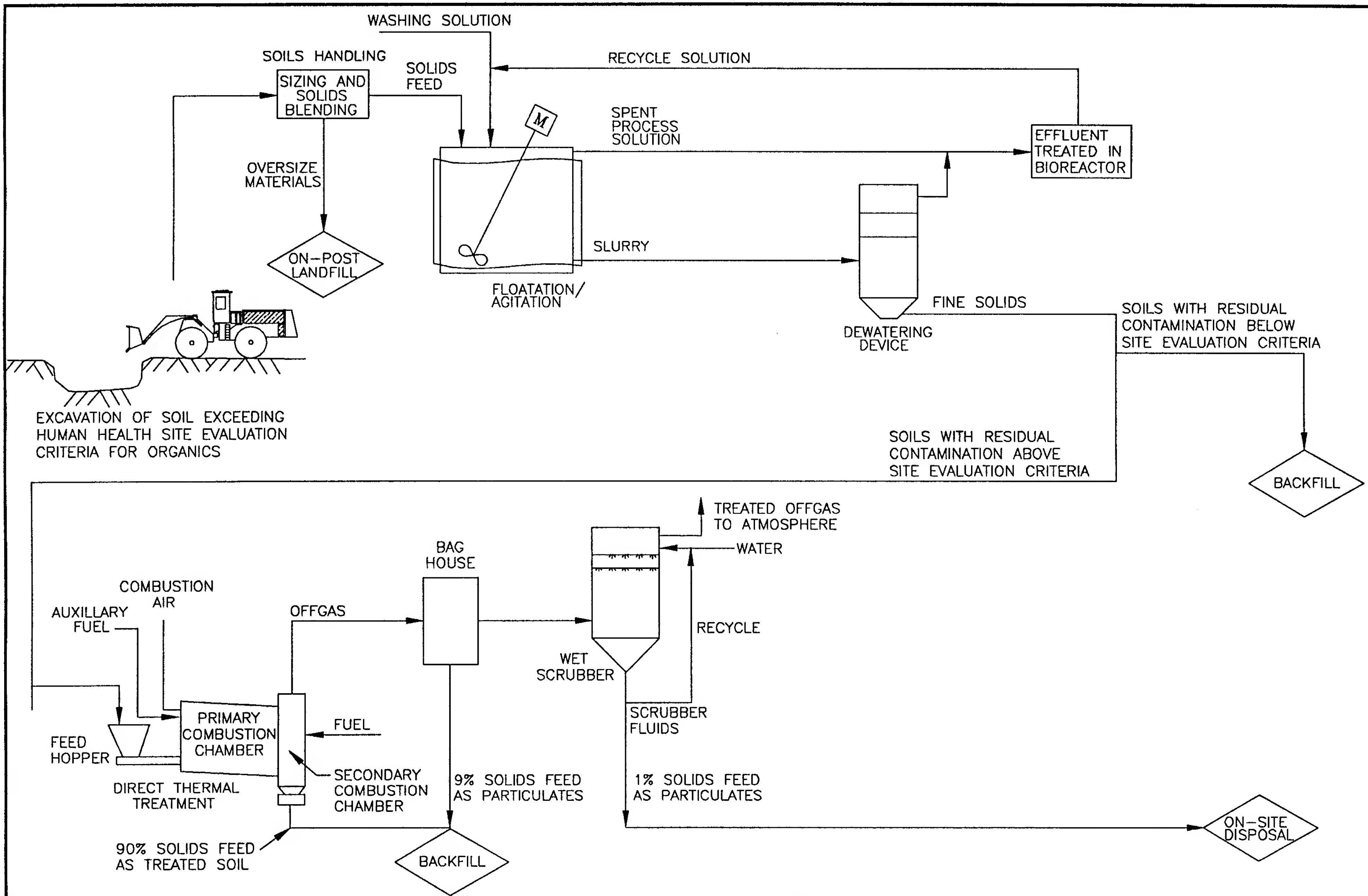
Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.5-1 Alternative B6 Direct Thermal Desorption	Prepared by: Ebasco Services Incorporated



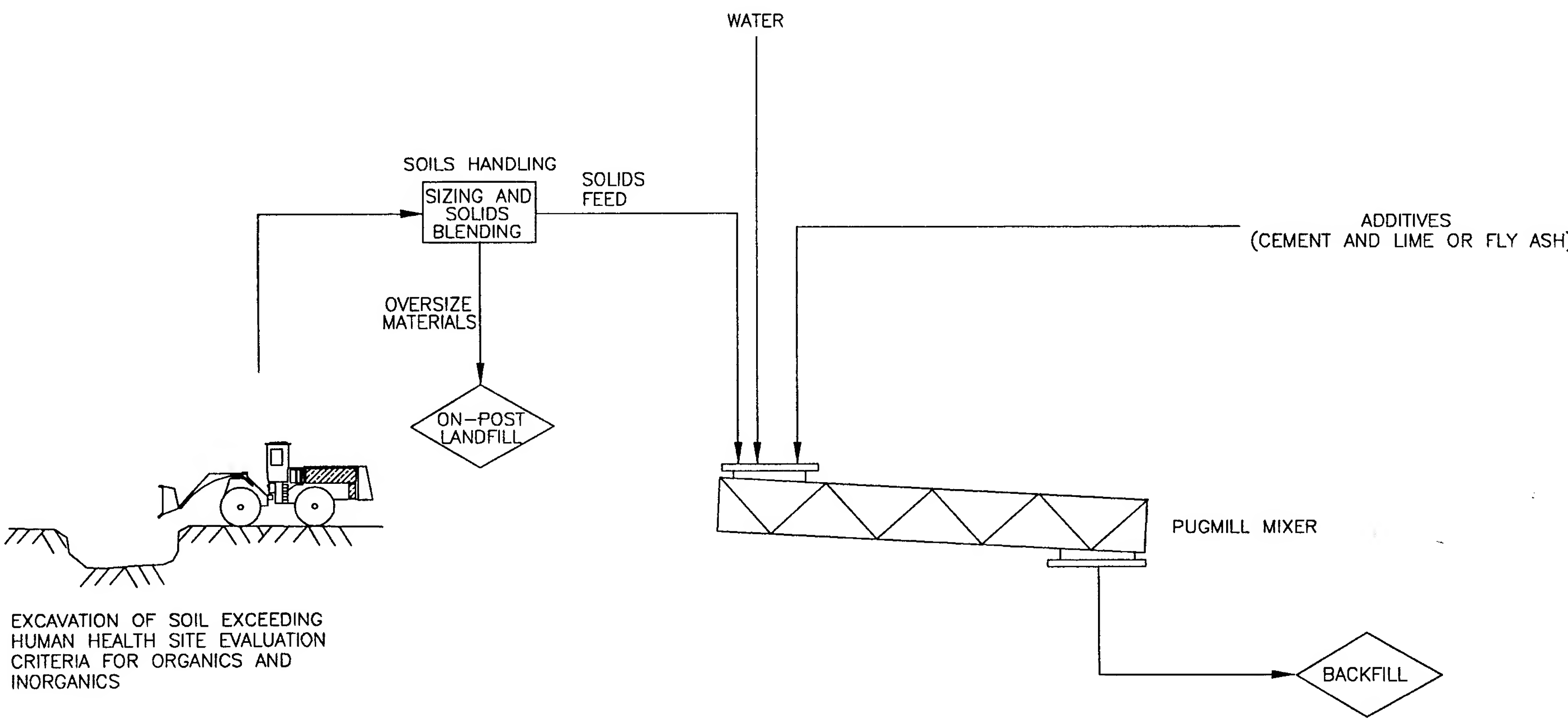
Prepared for: Office for the Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-1 Alternative 8 Direct Soil Washing; Direct Solidification/Stabilization	Prepared by: Ebasco Services Incorporated



Prepared for: Office for the Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-2 Alternative 8a Direct Soil Washing	Prepared by: Ebasco Services Incorporated

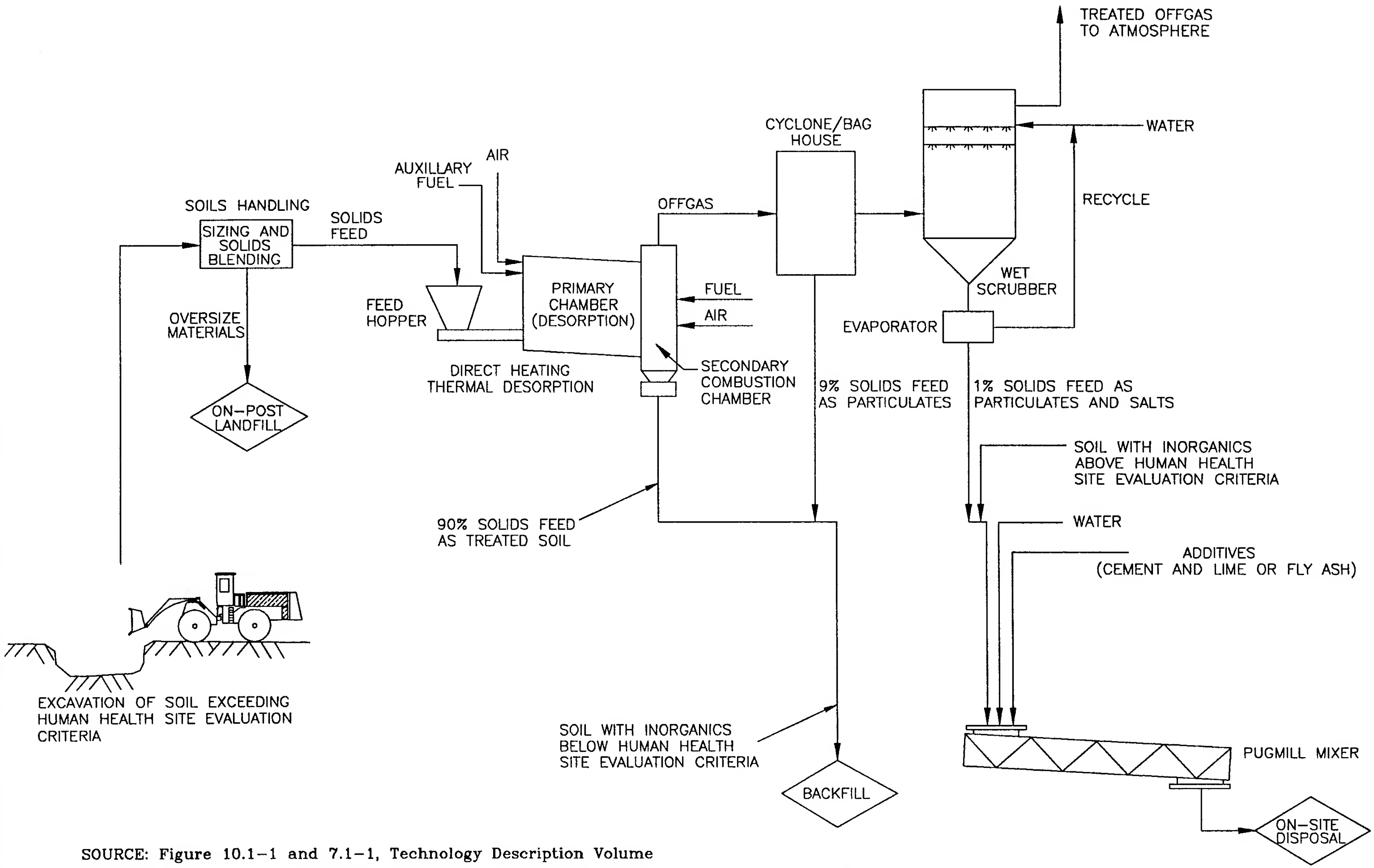


Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-3 Alternative 9a Direct Soil Washing; Direct Thermal Desorption	Prepared by: Ebasco Services Incorporated



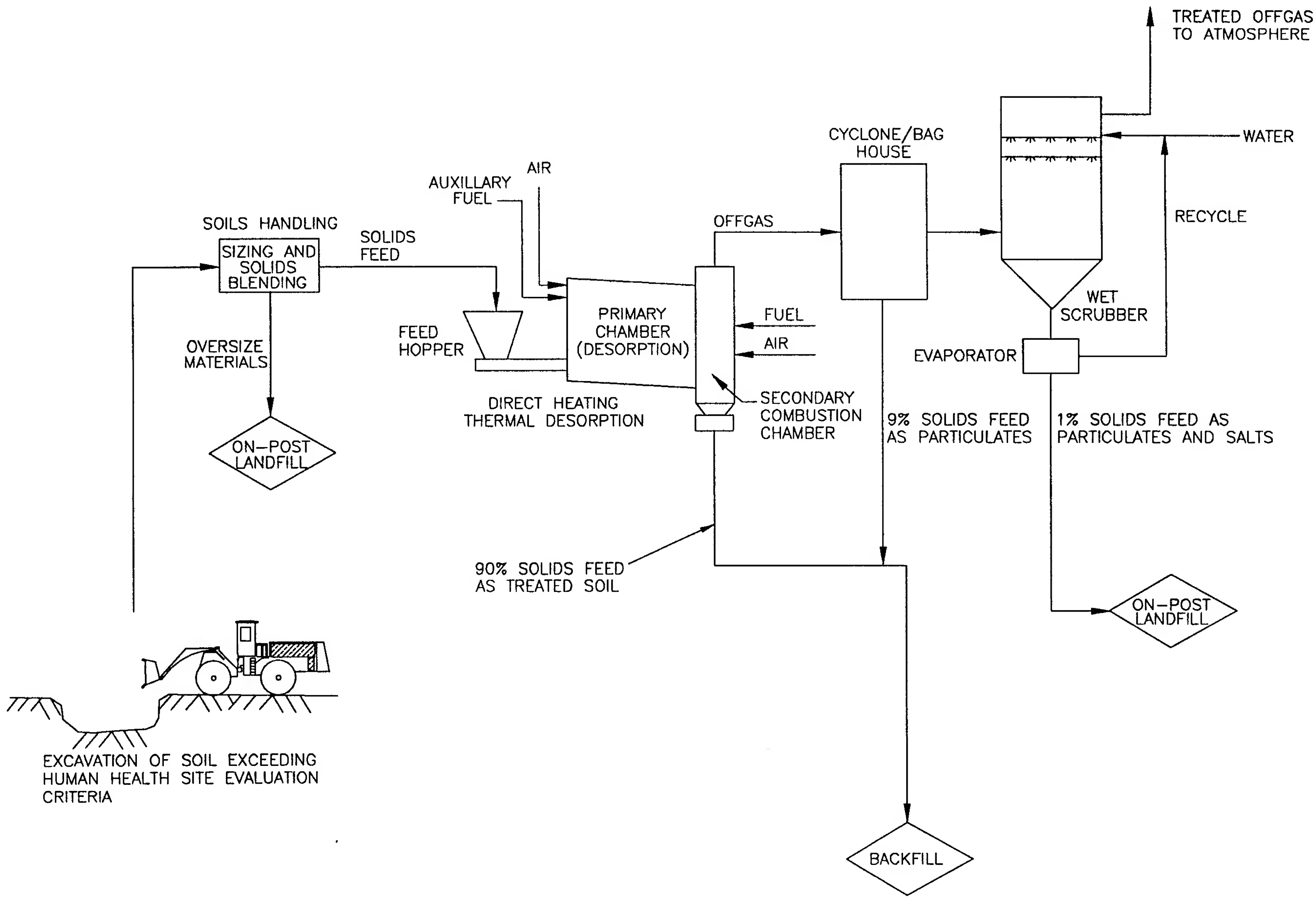
SOURCE: Figure 10.1-1, Technology Description Volume

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-4 Alternative 10 Direct Solidification/Stabilization	Prepared by: Ebasco Services Incorporated



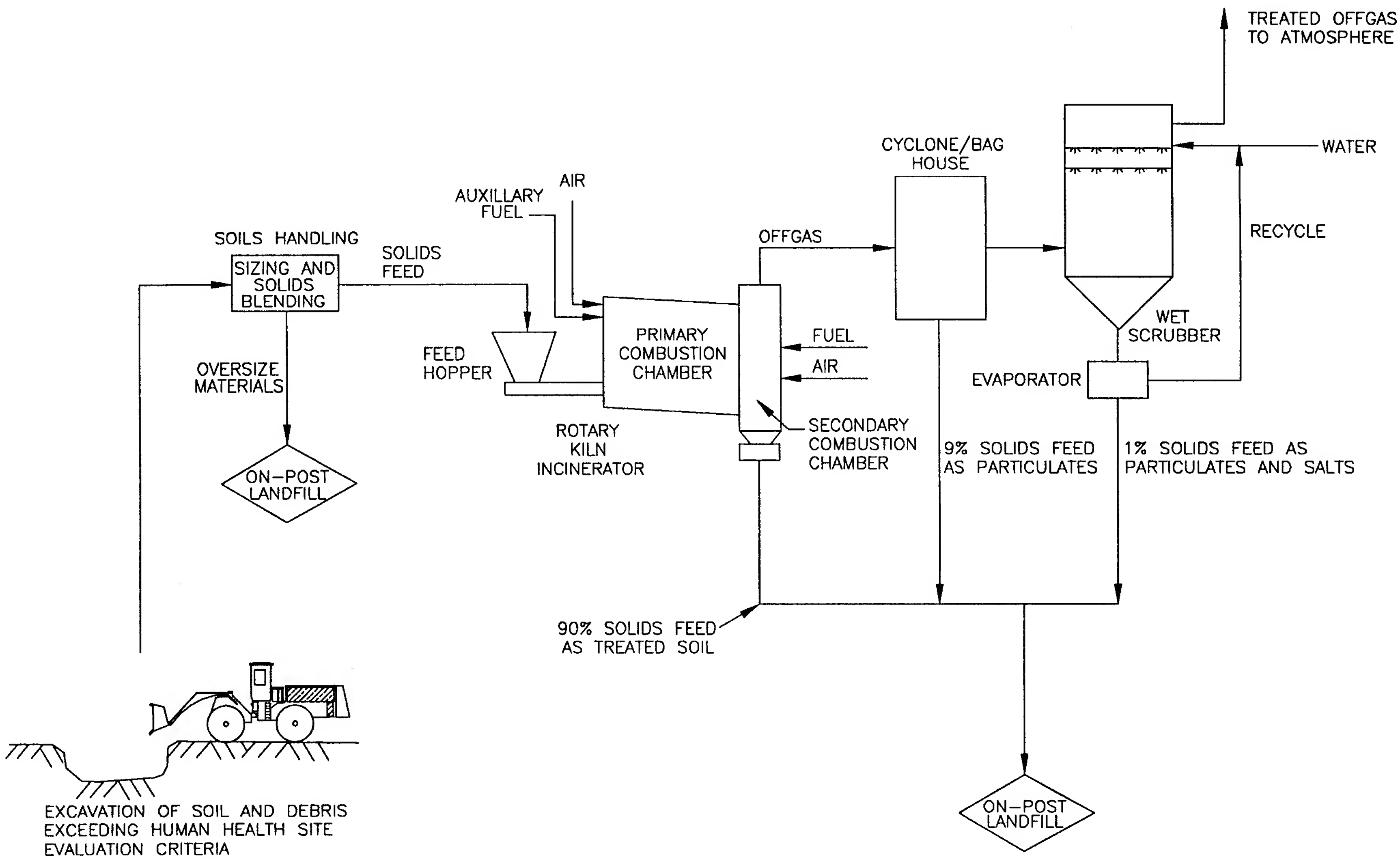
SOURCE: Figure 10.1-1 and 7.1-1, Technology Description Volume

Prepared for: U.S Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-5 Alternative 13 Direct Thermal Desorption; Direct Solidification/Stabilization	Prepared by: Ebasco Services Incorporated



SOURCE: Figure 7.1-1, Technology Description Volume

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-6 Alternative 13a Direct Thermal Desorption	Prepared by: Ebasco Services Incorporated



Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-7 Alternative 14 Incineration/Pyrolysis; Landfill	Prepared by: Ebasco Services Incorporated

5.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE MUNITIONS TESTING MEDIUM GROUP

The Munitions Testing Medium Group is composed of eight sites that were grouped based on similar site histories and the potential presence of UXO. There are no human health or biota exceedances present within the medium group. These sites, predominantly located in the eastern portions of RMA, were used for the testing and destruction of nonchemical munitions. These sites typically contain slag, debris, and potential UXO in the upper 2 ft of soil, and therefore represent potential physical hazards. One of the sites (ESA-4a) was an impact area for mortars and may contain HE-filled UXO at depths to 6 ft. Figure 5.0-1 shows the locations of the sites comprising this medium group.

During the DSA, alternatives were developed and screened based only on the general characteristics of the medium group. During the DAA, the characteristics of the medium group–including site configuration and potential presence of UXO–were evaluated to determine whether any modifications to the range of retained alternatives from the DSA would be appropriate, but none were required. Accordingly, individual subgroups were not developed for these sites, and the retained DSA alternatives apply to the Munitions Testing Medium Group as a whole.

The following sections present the characteristics of this medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection of a preferred alternative based on a comparative analysis of the alternatives. The preferred alternative is as follows:

- Alternative U4a—Excavation of UXO identified as a result of geophysical clearance and transportation of UXO to off-post Army facilities for detonation. Excavation and disposal of metallic debris in the on-post landfill.

In addition to the Munitions Testing Medium Group, UXO may be found at other sites in RMA including sites in the Basin A, Disposal Trenches, South Plants, and Undifferentiated Medium Groups. However, the areas with potential UXO in these medium groups generally overlap with

human health and/or biota exceedances, and UXO is dealt with as part of the human health or biota alternatives for these medium groups.

5.1 MEDIUM GROUP CHARACTERISTICS

The Munitions Testing Medium Group is composed of sites CSA-2c (Munitions Testing Area), CSA-2d (Incinerator NN 3601), ESA-1a (Section 19 Surface Burn), ESA-1b (Section 20 Surface Burn), ESA-1c (Section 29 Surface Burn), ESA-1d (Section 30 Surface Burn), ESA-4a (Impact Area), and ESA-4b (Demolition Area). These sites, primarily located in the Eastern Study Area, were used to test or destroy munitions. Table 5.1-1 presents a summary of detections for samples taken at sites in this medium group; none exceed the Biota or Human Health SEC. Agent-filled munitions are not expected to be found here based on site histories (EBASCO 1992a/RIC92017R01).

UXO may potentially be found at all the sites in this medium group (Figure 5.0-1). An area of 270,000 square yards (SY) of this medium group may contain HE-filled UXO (Table 5.0-1). The UXO is expected to occur in the 0- to 2-ft depth interval except at site ESA-4a, where it may occur at depths of up to 6 ft. Under the assumption that 0.1 percent of this total soil volume actually contains UXO the volume of soil with UXO is estimated at 450 BCY for this medium group. The volume of metallic debris anticipated for this medium group is 90,000 BCY based on the depth of debris identified at these sites during the RI. Volume and area calculations for this medium group are summarized in Appendix A.

The sites within the Munitions Testing Medium Group have poor- to moderate-quality habitat based on the types of vegetation encountered. In most of the alternatives developed for this medium group, the surface debris is removed and the areas disturbed during remedial actions are revegetated in accordance with a refuge management plan. In most instances, the overall habitat is improved, which should offset the short-term loss of habitat resulting from remedial actions.

5.2 EVALUATION OF ALTERNATIVES

The four alternatives for the Munitions Testing Medium Group vary in approach from no action to treatment. The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA.

5.2.1 Alternative U1: No Additional Action

Alternative U1: No Additional Action (Provisions of FFA) applies to 270,000 SY of potential UXO presence area in the Munitions Testing Medium Group. No action is taken under this alternative to reduce potential human or biota exposure to UXO. Five-year site reviews to assess the status of UXO left in place are required.

Table 5.2-1 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. Human Health and Biota RAOs are not achieved without controls being initiated because the physical hazards associated with UXO remain. However, the residual risk is low due to the small volume of soil (450 BCY) estimated to contain UXO. No action is taken to improve the poor- to moderate-quality habitat present in the medium group. The total estimated present worth cost for this alternative is $170,000. Table B1.1-U1 presents the details of costing for this alternative.

5.2.2 Alternative U2: Caps/Covers

Alternative U2: Caps/Covers (Soil Cover) addresses the containment of 270,000 SY of potential UXO presence area. A surface sweep is conducted with a metal detector to ensure that the surface sweeps conducted in the RI did not leave undetected UXO in the near-surface soils. If any UXO is identified, it will be addressed by Alternative U4a (based on the small quantity expected). Prior to installing the soil cover, the area is crowned with fill to facilitate surface-water runoff. The area is then covered with a layer of common fill, including 6 inches of topsoil, and revegetated in accordance with a refuge management plan. The soil cover provides a physical barrier to protect human and biota receptors from directly contacting potential UXO. The fill materials are excavated from an on-post borrow area, and the topsoil is imported from

off site. The installation of the cover takes less than 1 year to complete. Maintenance activities ensure the continued integrity of the soil cover.

Table 5.2-2 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs through the installation of a physical barrier, and there is a low residual risk after potential UXO areas are covered. Site reviews and long-term cover maintenance are required. Revegetation of disturbed areas improves poor- to moderate-quality habitat, and habitat is restored at the borrow area. Burrowing animals are removed from the site to protect the integrity of the soil cover. The total estimated present worth cost of this alternative is $8,700,000. Table B1.1-U2 details the costing for this alternative.

5.2.3 Alternative U3a: Detonation

Alternative U3a: Detonation (On-Post Detonation) addresses the treatment of 450 BCY of soils estimated to contain HE-filled UXO. UXO are specially packaged and transported to on-post facilities for detonation. The initial steps in the process are to identify UXO in the munitions area using geophysics (to identify magnetic sources) and excavate the soils containing UXO using specialized techniques. The HE-filled UXO are taken to the closest on-post site for detonation and the debris remaining after detonation are collected by conventional earth-moving equipment and landfilled on post.

Once the UXO has been removed from the site, the top 1 ft of soil from the entire site area (270,000 SY) is removed to collect any remaining debris. This soil/debris (90,000 BCY) is transported to the on-post nonhazardous waste landfill. A layer of topsoil is placed on the excavated areas, and the topsoil is revegetated with native grasses. The on-post landfill takes 1 year to construct and is fenced to keep wildlife out. Long-term activities after landfill closure include maintenance, leachate collection and treatment, and groundwater monitoring.

Table 5.2-3 details the evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves the RAOs and the NCP goal for irreversible reduction of TMV. The

alternative also complies with action- and location-specific ARARs for air emissions sources; landfill siting, design, and operation; and Army regulations regarding HE-filled UXO demilitarization. However, it requires the on-post detonation of HE-filled UXO, which may not be easily accepted by the community, and involves the short-term risks of excavating and handling UXO. Habitat is improved at the site following remediation. The clearance, removal, and transportation of UXO and revegetation of the site is anticipated to be complete within 2 years. The total estimated present worth cost of this alternative is $6,100,000. Table B1.1-U3 details the costing for this alternative.

5.2.4 Alternative U4a: Detonation

Alternative U4a: Detonation (Off-Post Army Facililty) provides for treatment of 450 BCY of soils estimated to contain UXO. UXO is removed and specially packaged on post and then transported to off-post Army facilities specifically designed for UXO demilitarization.

The initial step in the process is to identify UXO in the munitions area using geophysics and to carefully excavate the soils containing HE-filled UXO. HE-filled UXO rendered safe for transport is shipped by truck or rail to Fort Carson in Colorado Springs, Colorado for demilitarization. The Army's Explosive Ordnance Detail is responsible for all of the on- and off-post handling, packaging, and transportation of UXO. Any HE-filled UXO not considered safe for transport is handled in accordance with the procedures outlined in Section 5.2.3.

Once the UXO has been removed from the site, the top 1 foot of soil from the entire site area (270,000 SY) is removed to collect any remaining debris. This soil/debris (90,000 BCY) is transported to the on-post nonhazardous waste landfill. A layer of topsoil is placed on the excavated areas, and the topsoil is revegetated with native grasses. The on-post landfill takes 1 year to construct and is fenced to keep wildlife out. Long-term activities after landfill closure include maintenance, leachate collection and treatment, and groundwater monitoring.

Table 5.2-4 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves the RAOs and the goal of the NCP for irreversible reduction of TMV. The alternative also complies with action- and location-specific ARARs for landfill siting, design, and operation; state regulations on transportation of explosives; and Army regulations regarding the transport and demilitarization of HE-filled UXO (AMC-R 385-131). There are short-term risks for excavating, handling, and shipping UXO off post. These operations are expected to be completed in 2 years. Habitat is improved at the site following remediation. The total estimated present worth cost of this alternative is $6,700,000. Table B1.1-U4 details the costing for this alternative.

5.3 SELECTION OF PREFERRED ALTERNATIVE

There are 450 BCY of soils in the Munitions Testing Medium Group that are expected to contain UXO, primarily in the 0- to 2-ft depth interval. An additional 90,000 BCY are anticipated to contain metallic debris from testing and destruction of munitions. Agent-filled munitions are not expected to be found in this subgroup based on site histories.

Sites within this medium group have poor- to moderate-quality habitat based on the vegetation that is present. Alternatives that disrupt habitat include revegetation and restoration following remediation; therefore, significant habitat impacts are not anticipated.

Selection of the preferred alternative must include consideration of the physical hazards and long-term risks involved in leaving UXO in place versus the short-term risks to site workers and the general public from excavation and detonation operations. Risks to site workers and the general public can be minimized with appropriate safety equipment and procedures.

Alternative U1: No Additional Action does not address potential physical hazards associated with UXO and so does not achieve RAOs; it was therefore eliminated from further consideration as the preferred alternative. The three remaining alternatives achieve RAOs and meet the two EPA threshold criteria for the DAA: they are protective of human health and the environment

and they comply with action- and location-specific ARARs. These three alternatives, however, differ in the five balancing criteria.

The containment alternative, Alternative U2: Caps/Covers, does not treat UXO, but does interrupt exposure pathways. The other two treatment alternatives have similar components and both comply with the Army regulations for the management of UXO and dispose of 90,000 BCY of debris in the on-post landfill. Alternative U4a: Detonation (Off-Post Army Facility) differs from Alternative U3a: Detonation (On-Post Detonation) in that the off-post treatment uses existing Army facilities and so results in a lower risk to site workers, although there is a public risk related to off-post transportation. Furthermore, the detonation of UXO at off-post facilities may be more acceptable to the community due to the perceived risks associated with on-post detonation. The small volume of soil containing UXO (450 BCY) does not limit the feasibility of off-post transportation.

The preferred alternative for the Munitions Testing Medium Group is Alternative U4a: Off-Post Incineration. This alternative is protective since the UXO is removed and treated at a lower risk to workers. This alternative uses existing facilities, may be more acceptable to the community, and complies with Army regulations for UXO demilitarization.

Table 5.0-1 Characteristics of the Munitions Testing Medium Group

Characteristic	Munitions Testing Medium Group
Contaminants of Concern	
Human Health	none
Biota	none
Exceedance Area (SY)	
Total	0
Human Health	0
Biota	0
Potential Agent	not applicable
Potential UXO	270,000
Exceedance Volume (BCY)	
Total	0
Human Health	0
Organic	0
Inorganic	0
Principal Threat	0
Biota	0
Potential Agent	not applicable
Potential UXO	450
Depth of Contamination (ft)	
Human Health	not applicable
Biota	not applicable

Table 5.1-1 Frequency of Detections for Munitions Testing Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	138	136	98.6%	2	1.4%	0	0.0%	0	0.0%	0	0.0%
Benzene	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	138	138	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroacetic Acid	2	2	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlorobenzene	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroform	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	138	138	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
p,p,DDT	138	137	99.3%	1	0.7%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	124	124	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	5	5	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	139	139	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	138	135	97.8%	3	2.2%	0	0.0%	0	0.0%	0	0.0%
Endrin	138	137	99.3%	1	0.7%	0	0.0%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	138	138	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Isodrin	138	138	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Methylene Chloride	8	6	75.0%	2	25.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	5	5	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Toluene	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	127	108	85.0%	18	14.2%	1	0.8%	0	0.0%	0	0.0%
Cadmium	127	110	86.6%	17	13.4%	--	--	0	0.0%	0	0.0%
Chromium	127	14	11.0%	108	85.0%	--	--	5	3.9%	0	0.0%
Lead	127	90	70.9%	37	29.1%	--	--	0	0.0%	0	0.0%
Mercury	145	128	88.3%	17	11.7%	0	0.0%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.

Table 5.2-1 Evaluation of Alternative U1: No Additional Action (Provisions of FFA) for the Munitions Testing Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Does not achieve Human Health or Biota RAOs as soils with potential UXO presence remain as controls are not implemented. No unacceptable cross-media or short-term impacts.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs as site reviews achieved.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Munitions Testing Medium Group not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Small volume of anticipated UXO remain in soil.
b) Adequacy and reliability of controls	b) No controls implemented. Site reviews required.
c) Habitat impacts	c) Habitat quality not improved. Existing poor- to moderate-quality habitat not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction of contaminant volume or mobility; 270,000 SY of soils with potential UXO remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative. Soils with potential UXO remain.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dust or vapor emissions.
c) Environmental impacts of remedial actions	c) No environmental impacts. Existing poor- to moderate-quality habitat not impacted by remedial alternative.
d) Time until RAOs are achieved	d) RAOs not achieved. Soils with potential UXO presence remain on site.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) No services required for monitoring, except for site reviews.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $170,000
d) Total	d) $170,000

Table 5.2-2 Evaluation of Alternative U2: Caps/Covers (Soil/Cover) for the Munitions Testing Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; soils with potential UXO presence contained by soil cover preventing human and biota exposure; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-5	a) Complies with action-specific ARARs regarding construction of soil cover layers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Munitions Testing Medium Group not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 270,000 SY of soils with potential UXO presence contained through installation of 270,000 SY soil cover.
b) Adequacy and reliability of controls	b) Adequate controls. Site reviews required for soil cover; erosion control and vegetative cover maintenance required; high confidence in engineering controls of soil cover.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves poor- to moderate-quality habitat; relocation of burrowing animals helps preserve integrity of cover and prevent exposure.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Human and biota exposure pathways interrupted through installation of 270,000 SY soil cover.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Reduction in exposure pathways and hazards reversible if cover degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during UXO screening and cover installation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Habitat disturbance limited to area of poor- to moderate-quality habitat; new vegetative layer improves habitat except for burrowing animals.
d) Time until RAOs are achieved	d) 1 year. Installation of 270,000 SY soil cover feasible within 1 year.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably maintained thereafter; additional remedial action easily undertaken for soils left in place, although cap adds to overall site volume.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of soil cover design and construction regulations.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment readily available for soil cover construction; soil covers well demonstrated at full scale.

Table 5.2-2 Evaluation of Alternative U2: Caps/Covers (Soil/Cover) for the Munitions Testing Medium Group

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $5,900,000
c) Long-term	c) $2,900,000
d) Total	d) $8,700,000

Table 5.2-3 Evaluation of Alternative U3a: Detonation (On-Post Detonation) for the Munitions Testing Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment of UXO on post and containment of debris in on-post landfill; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-9, and A-10)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Munitions Testing Medium Group, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding UXO demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 450 BCY of soils with HE-filled UXO demilitarized on post; 90,000 BCY of untreated soils/debris contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls of landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves poor-to moderate-quality habitat, but eliminates poor-quality habitat at landfill.
4. Reduction in TMV through treatment	
a) Treatment process used and materials treated	a) 450 BCY of soils with HE-filled UXO detonated on post; exposure pathways interrupted through containment of 90,000 BCY of untreated soils/debris in on-post landfill.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) TMV reduction by detonation irreversible for HE-filled UXO; mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment and specialized handling procedures adequately protects workers during UXO clearance, excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact on biota due to existing poor-quality habitat.
d) Time until RAOs are achieved	d) 2 years. Detonation of 450 BCY of soils with UXO feasible within 1 year containment of 90,000 BCY of soil/debris feasible within 1 year after 1 year for construction of landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cells monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of incinerator and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Equipment, specialists, and materials readily available for construction of landfill; landfills well demonstrated at full scale.

Table 5.2-3 Evaluation of Alternative U3a: Detonation (On-Post Detonation) for the Munitions Testing Medium Group

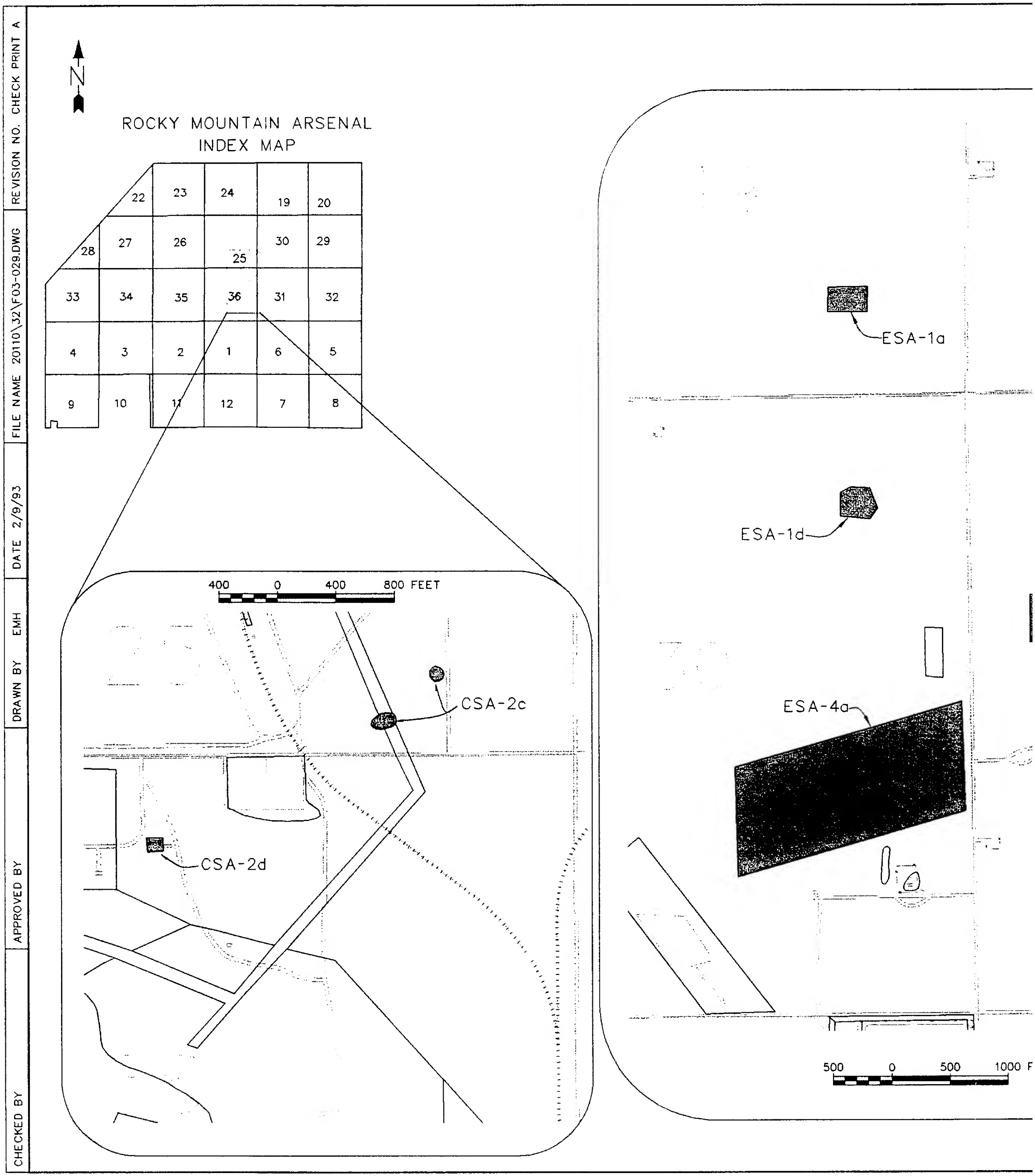
CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $1,400,000
b) Operating	b) $4,400,000
c) Long-term	c) $220,000
d) Total	d) $6,100,000

Table 5.2-4 Evaluation of Alternative U4a: Detonation (Off-Post Army Facility) for the Munitions Testing Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment of UXO off post and containment of debris in on-post landfill; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-9 and A-16)	a) Complies with action-specific ARARs including state regulations on transportation of explosives and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Munitions Testing Medium Group and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding UXO transport and demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 450 BCY of soils with HE-filled UXO excavated and detonated off post; 90,000 BCY of untreated soil/debris contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves poor- to moderate-quality habitat at site, but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 450 BCY of soil with HE-filled UXO detonated off post, exposure pathways interrupted through containment of 90,000 BCY of untreated soils/debris in on-post landfill.
b) Degree and quantity of TMV reduction	b) (See a).
c) Irreversibility of TMV reduction	c) TMV reduction by demilitarization irreversible for UXO; mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative other than landfilled debris.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment and specialized handling procedures adequately protects workers during UXO clearance, excavation, packaging, and transportation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact on biota due to existing poor-quality habitat.
d) Time until RAOs are achieved	d) 2 years. Off-post demilitarization of 450 BCY of soils with UXO feasible within 1 year; containment of 90,000 BCY of soil/debris feasible within 1 year after 1 year for construction of landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; landfill cell monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of transportation of explosives and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several Army facilities (including Fort Carson, CO) available for demilitarization of HE-filled UXO; equipment, specialists, and materials readily available for construction of landfill and transportation of UXO; landfills well demonstrated at full scale.

Table 5.2-4 Evaluation of Alternative U4a: Detonation (Off-Post Army Facility) for the Munitions Testing Medium Group

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $1,500,000
b) Operating	b) $4,800,000
c) Long-term	c) $370,000
d) Total	d) $6,700,000


ROCKY MOUNTAIN ARSENAL
INDEX MAP
N
22 23 24 19 20
28 27 26 25 30 29
33 34 35 36 31 32
4 3 2 1 6 5
9 10 11 12 7 8
400 0 400 800 FEET
CSA-2c
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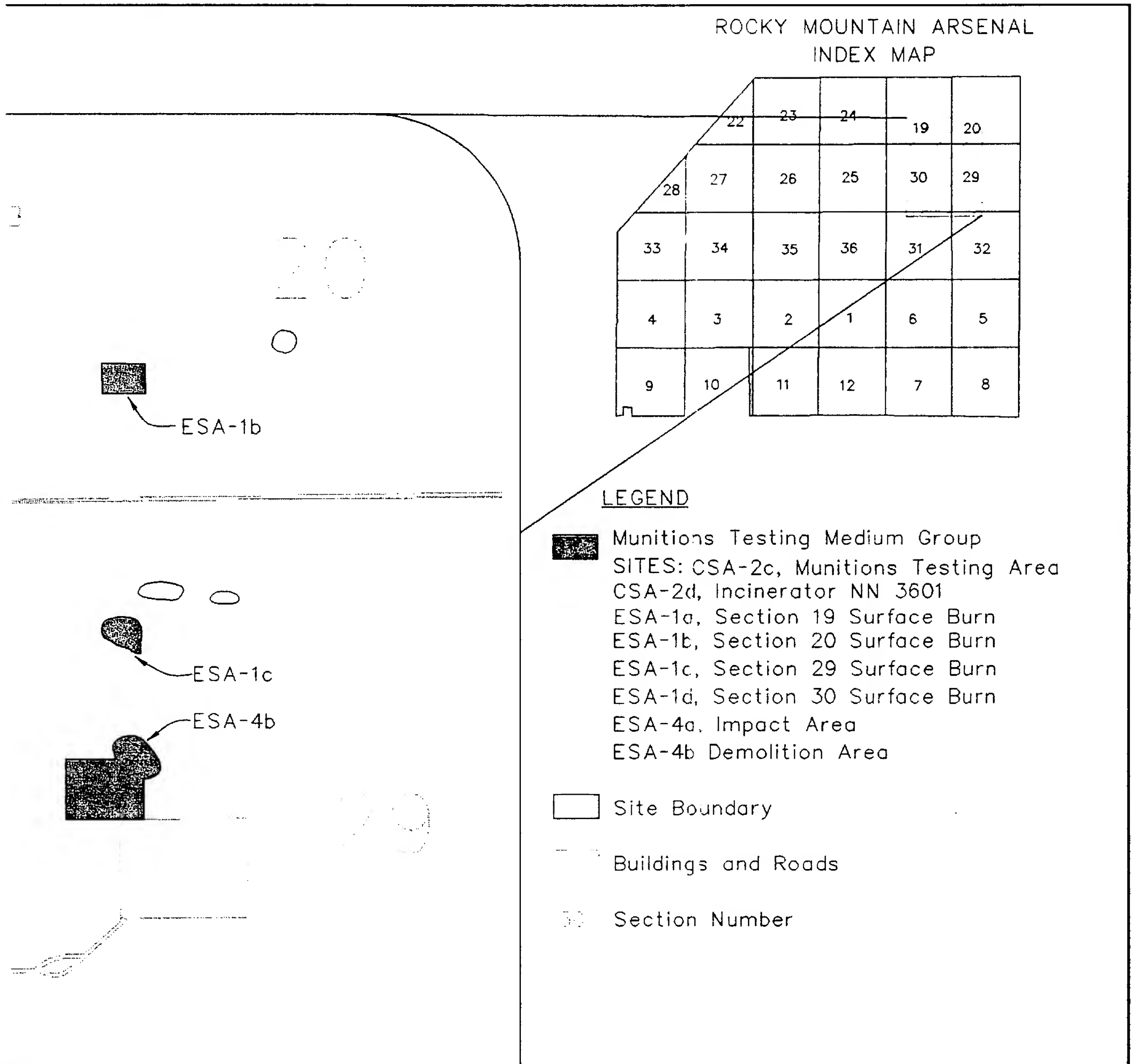

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 5.0-1

Site Locations
Munitions Testing Medium Group

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated

6.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE AGENT STORAGE MEDIUM GROUP

The Agent Storage Medium Group is composed of 15 sites that were grouped together based on similar site histories and uses. They are considered exceedance sites based on the potential presence of Army chemical agent, although some of the sites also contain COCs exceeding Human Health and Biota SEC. The sites in this medium group include former agent storage areas located in the eastern portion of RMA, ditches in the vicinity of the agent storage areas, and the North Plants GB manufacturing area. Although agent has not been detected at these sites, they are presumed to potentially contain agent within the uppermost 5 to 10 ft of soil based on historical usage or based on the presence of agent breakdown products. Based on the site type and contamination pattern, within this depth range the sites within this medium group are divided into two subgroups, the North Plants Subgroup and the Toxic Storage Yards Subgroup. Figure 6.0-1 shows the locations of the sites in the North Plants Subgroup and Figure 6.0-2 those within the Toxic Storage Yards Subgroup.

The human health exceedance contaminants in this medium group are arsenic and chloroacetic acid (CLC2A). In addition, OCPs and mercury were found at levels that exceed Biota SEC only. The RISR identifies the sites within the North Plants Subgroup as potential sources of groundwater contamination (EBASCO 1992a/RIC 92017R01). Table 6.0-1 presents the characteristics of this medium group, including exceedance volumes and COCs. Appendix A presents volume and exceedance area calculations.

In the DSA, alternatives were developed and screened based on the general characteristics of the medium group as a whole. In the DAA, the retained alternatives were reviewed to ensure that they apply to each subgroup. The characteristics of each subgroup—including contaminants and concentrations, site configuration, depth of contamination, and potential presence of agent—were evaluated to determine whether any modifications to alternatives would be appropriate, but no changes were warranted for either of the subgroups.

The following sections present the characteristics of each subgroup as well as an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990), and the selection of a preferred alternative for each subgroup based on a comparative analysis of the alternatives. The preferred alternatives are as follows:

- North Plants: Alternative A4—Excavation of agent-contaminated soils after screening for areas with potential agent presence. On-post treatment of agent-contaminated soils by rotary kiln incineration and disposal of isolated human health and biota exceedances in an on-post landfill.

- Toxic Storage Yards: Alternative A4—Excavation of agent-contaminated soils after screening for areas with potential agent presence. On-post treatment of agent-contaminated soils by rotary kiln incineration and disposal of isolated human health and biota exceedances in an on-post landfill.

In addition to the Agent Storage Medium Group, agent may be found at other sites at RMA. These include areas within the Basin A, Sewer Systems, Disposal Trenches, Lime Basins, South Plants, and Undifferentiated Medium Groups. Appendix A describes the sites contained within these medium groups as well as the potential areas, depths, and volumes of agent-contaminated soils.

6.1 NORTH PLANTS SUBGROUP CHARACTERISTICS

The North Plants Subgroup is composed of sites NPSA-3 (GB Manufacturing Area), NPSA-5 (Special Weapons Plant), NPSA-6 (Underground Spill Area), Building 1601 (GB and Bomb Plant), Building 1606 (Cluster Assembly Building), and Building 1607 (Warehouse) (Figure 6.0-1). These sites potentially contain agent based on historical usage or based on the presence of agent breakdown products. In addition, these sites contain isolated human health and biota exceedances.

Table 6.1-1 provides a summary of contaminants, concentrations, and the corresponding exceedance values for the subgroup. Table 6.1-2 presents the frequency of detections for contaminants above both the Human Health and Biota SEC. Arsenic is the only contaminant

above the Human Health SEC for this subgroup and is found only in two isolated detections. The Biota SEC are exceeded by arsenic, mercury, and isolated detections of OCPs at depths ranging from 0 to 2 ft below the ground surface.

The North Plants Subgroup sites were identified as historical sources of groundwater contamination in the RISR (EBASCO 1992a/RIC 92017R01); however, these sites are not expected to be significant as ongoing sources of contamination to groundwater plumes. The groundwater plume migrating to the north that originates in North Plants is being collected and treated at the North Boundary Containment System. The Water DAA is evaluating several remedial alternatives for this plume as part of the North Boundary Plume Group. Although the North Boundary Containment System might be positively impacted by the remediation of soils in the North Plants Subgroup, it is unlikely that the boundary system could be abandoned due to the contaminant mass already present in the aquifer.

Areas with potential agent presence in the North Plants Subgroup may be located below existing structures at RMA. Alternatives for these structures, which belong to the No Future Use, Agent History Medium Group, are being analyzed in the Structures DAA (Figure 6.1-1). Most of the structures in North Plants are demolished in accordance with the chemical agent treaties as discussed in Section 3.1 of the Structures DAA. The treatment of soils beneath these structures requires the removal of structural debris following demolition. The containment of the soils with potential agent presence by a soil cover, as described in Section 6.2.2, allows the containment of structural debris beneath the cap along with the soil areas with potential agent presence following demolition of the structures.

The sites within the North Plants Subgroup contain poor-quality habitat areas based on the types of vegetation encountered. In most of the alternatives developed for this subgroup, the areas disturbed during remedial actions are revegetated with native grasses in accordance with a refuge

management plan. Therefore, the overall habitat is improved, which should offset the short-term loss of habitat resulting from remedial actions.

6.2 NORTH PLANTS SUBGROUP EVALUATION OF ALTERNATIVES

The four alternatives for the North Plants Subgroup vary in approach from no action to treatment. The following subsections present a description of each alternative and an evaluation of the alternative against the DAA criteria listed in the NCP.

6.2.1 Alternative A1: No Additional Action

Alternative A1: No Additional Action (Provision of FFA) applies to an area of 28,000 SY of the North Plants Subgroup beneath which agent potentially occurs. No action is taken under this alternative to reduce potential exposure to agent. The soils with isolated human health exceedance volumes of arsenic and the soils with biota exceedance volumes remain in place. Since no action is taken for the soils, there is no impact on the preferred structures alternative. Five-year reviews and groundwater monitoring are required to assess the status of potential agent and other COCs remaining in these sites.

Table 6.2-1 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. Human Health and Biota RAOs are not achieved because the potential for agent-contaminated soils remains and the isolated human health and biota exceedances are not addressed. The residual risk is low due to the small anticipated volume of soil containing agent (63 BCY). No action is taken to improve the poor-quality habitat present in the North Plants Subgroup, or to reduce the potential for future migration of contaminants to groundwater. The total estimated present worth cost of the alternative is $180,000. Table B2.1-A1 details the costing for this alternative.

6.2.2 Alternative A2: Caps/Covers

Alternative A2: Caps/Covers (Soil Cover) involves placing a 28,000-SY soil cover over areas with potential agent presence and with isolated human health and biota exceedances. The soil subgrade is compacted before any cover materials are installed, and the area receiving the soil cover is crowned to facilitate surface-water runoff. The structural debris from the demolition of North Plants buildings is removed or placed under the soil cover. As described in Section 6.1 of the Technology Description Volume, the area is then covered by a 4-ft soil/vegetation layer including 6 inches of topsoil. The topsoil layer is revegetated with native grasses. The soil/vegetation layer acts as a physical barrier to protect human and biota receptors from directly contacting soils with potential agent presence. The fill material is excavated from an on-post borrow area, and the topsoil is obtained off post. The covering operations take less than 1 year to complete. Long-term maintenance activities ensure the continued integrity of the soil cover.

Table 6.2-2 details the evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs through installation of a physical barrier to interrupt exposure pathways. Habitat is improved at the site following remediation, but burrowing animals are removed from the site to protect the integrity of the cover. Potential future migration of contaminants to groundwater is reduced. Approximately 1 year is required for the installation of the cover, and site reviews and long-term maintenance are required. The total estimated present worth cost of this alternative is $1,100,000. Table B2.1-A2 details the costing for this alternative.

6.2.3 Alternative A3: Soil Washing; Landfill

Alternative A3: Soil Washing (Solution Washing); Landfill (On-Post Landfill) addresses the 63 BCY of agent-contaminated soils anticipated to be found in the North Plants Subgroup through the process of caustic washing. Caustic washing is a physical/chemical treatment process option in which agent-contaminated soil is excavated, mixed with caustic wash fluids in an aboveground unit to degrade the agent, and then separated from the wash water. The process of caustic

washing of the agent-contaminated soils is performed in four caustic solution washing cycles to achieve an Army decontamination level of 3X (Section 4.4.3), a level that indicates that the soil has been surface decontaminated (AMC-R 385-131). The treated soil is placed in the on-post hazardous waste landfill.

The North Plants structures are demolished in accordance with the chemical agent treaties, and the resulting debris removed to allow access to the soils potentially containing agent. The next step in the alternative process is to screen the suspected areas for agent-contaminated soils, which is accomplished by closely-spaced drilling and field screening of the samples collected. The presence of agent is verified by analysis at the RMA laboratory. The agent-contaminated soils are then excavated and transported to the on-post caustic washing unit as described in Section 4.3.3. Any abandoned utilities encountered during excavation are removed and consolidated with the structural debris. The excavated areas are backfilled with fill material obtained from an on-post borrow area. Topsoil obtained from off post is placed on the backfilled areas and is revegetated with native grasses. The borrow area is also revegetated with native grasses, thereby restoring the value of the habitat.

The soils are placed in the washing unit and mixed with an 18-percent solution of sodium hydroxide (NaOH) at a ratio of 5:1 solution/soil for at least 30 minutes. Two waste streams are generated, the washed soil and the caustic solution. Caustic washing consists of four washing cycles, and each successive wash cycle requires the addition of 15 percent new caustic solution. An estimated 3,400 pounds (lbs) of agent degradation products and excess caustic solution is generated for each cubic yard of soil. The spent caustic is evaporated by spray drying, a process consisting of heating the solution with an infrared lamp to remove most of the water, and then completing the drying in an oven at 110°C. The capacity of the unit allows each wash cycle to treat approximately 5.6 BCY of agent-contaminated soils. A total of 1,100 BCY of salts with agent degradation products and excess NaOH is generated and transported to the on-post hazardous waste landfill along with the treated soils. The 610 BCY of soils with isolated human

health and biota exceedances are excavated and placed in the on-post hazardous waste landfill. A total of 1,800 BCY of salts, treated soils, and isolated exceedances are placed in the landfill. The on-post hazardous waste landfill requires 1 year to construct and is fenced to prevent wildlife from entering the area. The landfill undergoes long-term (30-year) maintenance and monitoring after closure.

Table 6.2-3 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs and irreversibly reduces contaminant TMV. Potential migration of contaminants to groundwater is reduced. The alternative also complies with the Army regulations regarding agent-contaminated materials. The habitat is improved at the site following revegetation. The removal and treatment of the agent-contaminated soils is anticipated to be completed within 2 years. The total estimated present worth cost of this alternative is $460,000. Table B2.1-A3 details the costing for this alternative.

6.2.4 Alternative A4: Incineration/Pyrolysis

Alternative A4: Incineration/Pyrolysis (Rotary Kiln) treats 63 BCY of agent-contaminated soils by on-post incineration. This alternative achieves the 5X criterion for materials containing agent as discussed in Section 4.4.4. The North Plants structures are demolished in accordance with the chemical agent treaties, and the resulting debris removed to allow access to the soils potentially containing agent. Areas with the potential presence of agent are screened using a drilling program to identify agent-contaminated soils. Soil samples collected during drilling are screened by field analytical methods for agent and sent to the RMA laboratory for verification. The soils identified as containing agent are excavated and transported to the rotary kiln incinerator. Any abandoned utilities encountered during excavation are removed and consolidated with the structural debris.

The centralized incineration facility is constructed in the northeast corner of Section 2. The facility requires approximately 2 years for construction and testing. The incinerator has a

throughput of approximately 470 BCY/day and a total solids residence time of 66 minutes at 760°C. Section 4.6.26 discusses emission controls for incinerator off-gases. The particulates from the scrubber blowdown, which constitute an estimated 1 percent of the solids feed, are placed in the on-post landfill along with the 610 BCY of soils with human health and biota exceedances in this subgroup. The excavations for the isolated exceedances are backfilled with borrow material from an on-post borrow area, covered with 6 inches of topsoil, and revegetated with natural grasses. The treated soils are backfilled and revegetated.

Table 6.2-4 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs since all contaminated soils are treated to destroy agent and the soils with isolated human health and biota exceedances are contained. The potential for the migration of contaminants to groundwater is reduced and Army regulations (AMC-R 385-131) regarding the treatment of materials containing agent are achieved. The habitat is improved at the site and is restored at the borrow area. The incineration of 63 BCY of soils requires less than 1 year, but the construction and testing of the facilities requires 2 years before the soils can be treated. Long-term maintenance and monitoring of the landfill is required. The estimated present worth cost of this alternative is $360,000. Table B2.1-A4 details the costing for this alternative.

6.2.5 Alternative A5: Soil Solvent Washing; Landfill

Alternative A5: Soil Washing (Solvent Washing); Landfill (On-Post Landfill) addresses the 63 BCY of agent-contaminated soils in the North Plants Subgroup through the process of solvent washing in a caustic solvent solution. Solvent washing is a physical/chemical treatment process option in which agent-contaminated soils are excavated, mixed, and agitated with organic solvent and sodium hydroxide wash fluids in an aboveground unit to degrade the agent and extract any other organic contaminants, and then separated from the wash solvent. Most of the solvent is recycled, and the waste solvent containing the extracted contaminants is disposed off post. The process of solvent washing of the agent-contaminated soils is assumed to require three 10-minute wash cycles to achieve an Army decontamination level of 3X (Section 4.3), which indicates that

the soils have been surface decontaminated (AMC-R 385-131). The treated soils are placed in the on-post hazardous waste landfill.

The North Plants structures are demolished in accordance with the chemical agent treaties, and the resulting debris removed to allow access to the soils potentially containing agent. The next step in the alternative process is to screen the suspected areas for agent-contaminated soils, which is accomplished by drilling and field screening. Agent presence is verified by analysis at the RMA laboratory. The agent-contaminated soils are then excavated and transported to the on-post solvent washing unit as described in Section 4.4.4. Any abandoned utilities encountered during excavation are removed and consolidated with the structural debris. The excavated areas are backfilled with fill material obtained from an on-post borrow area. Topsoil obtained off post is placed on the backfilled areas and is revegetated with native grasses. The borrow area is also revegetated with native grasses, thereby restoring the value of the habitat.

Excavated soils are screened to remove debris and oversized materials. The oversized material is fed to a size reduction unit as described in Section 7.3, then back into the feed stream. The maximum size of the feed material is 1/2 inch in diameter. The feed is then mixed and agitated with refrigerated TEA solvent and sodium hydroxide in a washer/dryer mixer vessel. As the solvent solubilizes the organic contaminants in the waste and the agent is hydrolyzed. The solids soil settles to the bottom of the vessel. The solvent/water mixture is removed and decanted. Decanted TEA is sent to a stripping column where the contaminants are separated from the TEA and the TEA is recycled to the washer/dryer mixing vessel. The water is sent to another stripping column to remove any residual TEA. The product water is later added back to the treated soils to return them to their pre-treatment moisture content. Three extractions are necessary to obtain the desired treatment level. The three extractions result in a total residence time of at least 30 minutes. Once treatment is achieved, product material are adjusted back to neutral pH and placed in the on-post landfill. The residual TEA containing agent breakdown

products and other organic contaminants is sent for off-post disposal. Less than 63 gallons of residual TEA containing concentrated contaminants is expected to be generated.

The 610 BCY of soils with isolated human health and biota exceedances are excavated and placed in the on-post hazardous waste landfill along with the treated soil. The on-post hazardous waste landfill requires 1 year to construct and is fenced to prevent wildlife from entering the area. The landfill undergoes long-term (30-year) maintenance and monitoring after closure.

Table 6.2-5 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs and irreversibly reduces contaminant TMV. Potential future migration of contaminants to groundwater is reduced. Although this alternative is also expected to comply with the Army regulations regarding agent-contaminated materials, this particular process has not previously been used to treat agent-contaminated material. Treatability studies will assess the ultimate effectiveness of the process. The habitat is improved at the site following revegetation. The removal and treatment of the agent-contaminated soils is anticipated to be completed within 2 years. The total estimated present worth cost of this alternative is $430,000. Table B2.1-A5 details the costing for this alternative.

6.3 NORTH PLANTS SUBGROUP SELECTION OF PREFERRED ALTERNATIVE

Agent is expected to be found in 63 BCY of soils in sites in the North Plants Subgroup. These sites are suspected to potentially contain agent based on historical usage or the presence of agent breakdown products. Isolated detections of arsenic above the Human Health SEC in 2 percent of the samples (Table 6.1-2) account for 67 BCY of human health exceedance volume. The Biota SEC are exceeded by arsenic, mercury, and isolated detections of OCPs, resulting in 540 BCY of biota exceedance volume. Sites in this subgroup contain poor-quality habitat based on the vegetation present. Areas disturbed by remedial actions are to be revegetated after remediation to restore and improve the habitat.

Selection of the preferred alternative for this subgroup must consider the exposure risks of leaving potential agent contamination in place versus the short-term risk to site workers of excavation and treatment. Risk to site workers can be minimized with appropriate health and safety equipment and procedures.

Alternative 1: No Additional Action does not achieve human health RAOs since the potential for exposure to agent remains. This alternative is eliminated from further consideration as the preferred alternative. The four remaining alternatives achieve RAOs and meet the two DAA threshold criteria—protection of human health and the environment, and compliance with action-specific and location-specific ARARs—although they differ in how they meet the five balancing criteria (Tables 6.2-1 through 6.2-5).

Alternative A2: Caps/Covers does not treat any materials, but it interrupts exposure pathways through containment. Alternative A5: Soil Washing (Solvent Washing); Landfill exhibits approximately the same cost ($430,000) as Alternative A3: Soil Washing (Solution Washing); Landfill ($460,000), and both alternatives utilize caustic solutions to degrade agent in soils. The equipment required for solvent/caustic washing is not readily available and is not well demonstrated at full scale. Alternative A3: Soil Washing; Landfill has the highest cost of the treatment alternatives for this subgroup ($460,000). The soil washing treatment for this alternative generates 1,100 BCY of residual salts requiring disposal. In addition, the treatment equipment for soil washing with caustic solutions is not commercially available for full-scale operation with a caustic solution. Alternative 4: Incineration/Pyrolysis has the lowest cost of the three treatment alternatives ($360,000). This alternative generates less than 1 BCY of off-gas particulates and salts that require disposal.

The preferred alternative for the North Plants Subgroup is Alternative 4: Incineration/Pyrolysis. This alternative is the most cost-effective alternative for this subgroup since agent-contaminated soils are treated and soils with isolated human health and biota exceedances are contained without

generating large quantities of residuals and at a lower cost. In addition, this alternative complies with Army regulations regarding agent-contaminated materials.

The alternatives retained for the remediation of the structures on the site incorporate demolition in accordance with the chemical agent treaties. The resulting debris can be landfilled, consolidated, or incinerated following demolition. Whichever alternative is chosen, the structural debris is removed in accordance with the chemical agent treaties prior to soil incineration (see Plate 2.3-1 in the Structures DAA). There are no soil/water interactions for the North Plants Subgroup based on the preferred groundwater alternative.

6.4 TOXIC STORAGE YARDS SUBGROUP CHARACTERISTICS

The Toxic Storage Yards Subgroup is composed of sites ESA-3a (Section 5 Storage Yard), ESA-3b (Section 6 Old Storage Yard), ESA-3c (Section 31 New Storage Yard), ESA-3d (Section 31 Toxic Yard Plots), ESA-3e (VX Demilitarization Pad), ESA-3f (Rail Loading Area), ESA-3g (Open Storage Area), ESA-3h (Open Storage Area), and ESA-3i (Toxic Storage Plots Ditch) (Figure 6.0-2). These sites are located in the Eastern Study Area, and potentially contain agent based on historical usage or based on the presence of agent breakdown products.

Soils in the Toxic Storage Yards Subgroup contain several isolated human health exceedances of CLC2A at depths ranging from 0 to 6 ft below ground surface. Table 6.4-1 provides a summary of contaminants, concentrations, and the corresponding exceedance values for the subgroup. Table 6.4-2 presents the frequency of detections for contaminants above the Human Health and Biota SEC. CLC2A exceeds the Human Health SEC in 4 samples at concentrations ranging from 120 to 130 ppm. Arsenic exceeds the Biota SEC at concentrations ranging from 75 to 270 ppm. Figure 6.4-1 shows the locations of these isolated human health and biota exceedances along with the areas of potential agent contamination. This subgroup contains approximately 270,000 SY of soils with the potential for agent contamination (Table 6.0-1).

Sites in the Toxic Storage Yards Subgroup have not been identified as historical sources of groundwater or surface-water contamination. Although several concrete pads are present within the subgroup, the remediation of contaminated soils in the toxic storage yards is not impacted by the presence of these structures since they are for the most part located outside of the potential agent presence area.

The sites within the Toxic Storage Yards Subgroup contain poor- to moderate-quality habitat areas based on the types of vegetation encountered. In most of the alternatives developed for this medium group, the areas disturbed during remedial actions are revegetated with native grasses in accordance with a refuge management plan, thereby improving the overall habitat. The short-term loss of habitat resulting from remedial actions is offset by overall habitat improvement. Two of the sites within this subgroup (Sites ESA-3a and ESA-3b) are located within the Bald Eagle Management Area. Although the habitat quality within these sites is poor to moderate based on vegetation type present, these sites are considered to be sensitive habitat based on their proximity to the bald eagle roosts. Therefore, any remedial actions for these sites must be coordinated with the USFWS to ensure that the disturbance of habitat is minimized.

6.5 TOXIC STORAGE YARDS SUBGROUP EVALUATION OF ALTERNATIVES

The four alternatives for the Toxic Storage Yards Subgroup vary in approach from no action to treatment. The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA.

6.5.1 Alternative A1: No Additional Action

Alternative A1: No Additional Action (Provisions of FFA) applies to 270,000 SY of the Toxic Storage Yards Subgroup which potentially contains agent. No action is taken under this alternative to reduce potential exposure to agent, and soils with isolated human health and biota exceedances remain in place. Since no action is taken for the soils, there is no impact on the

preferred structures alternative. Five-year reviews are required to assess the status of potential agent and other COCs remaining in these sites.

Table 6.5-1 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. Human Health and Biota RAOs are not achieved because the potential for exposure to agent-contaminated soil remains and soils with isolated human health and biota exceedances are not addressed. The residual risk is low due to the small anticipated volume of soils containing agent (450 BCY) and the low levels of isolated exceedances. No action is taken to improve the poor-quality habitat present in the Toxic Storage Yards Subgroup. The total estimated present worth cost of the alternative is $180,000. Table B2.2-A1 details the costing for this alternative.

6.5.2 Alternative A2: Caps/Covers

Alternative A2: Caps/Covers (Soil Cover) involves placing a soil cover over 270,000 SY of soils with potential agent presence as well as over soils with isolated human health and biota exceedances. The soil subgrade is compacted before any cover materials are installed, and the area receiving the soil cover is crowned to facilitate surface-water runoff. The area is covered by 4 feet of fill (which includes 6 inches of topsoil) and is then revegetated. The soil/vegetation cover provides a physical barrier to protect human and biota receptors from directly contacting soils with potential agent presence. The fill material is excavated from an on-post borrow area, and the topsoil is obtained off post. The covering operations require less than 1 year to complete, and long-term maintenance activities ensure the continued integrity of the soil cover.

Table 6.5-2 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs through containment. Habitat is improved following remediation at the site, but burrowing animals are removed from the site to protect the soil cover. One year is required for the installation of this 270,000-SY soil cover, and soil cover maintenance is required over the long term. The total estimated present worth of this alternative is $9,100,000. Table B2.2-A2 details the costing for this alternative.

6.5.3 Alternative A3: Soil Washing; Landfill

Alternative A3: Soil Washing (Solution Washing); Landfill (On-Post Landfill) addresses the treatment of 450 BCY of agent-contaminated soils in the Toxic Storage Yards Subgroup through the process of caustic washing. Caustic washing is a physical/chemical treatment process option in which agent-contaminated soil is excavated, mixed with caustic wash fluids in an aboveground unit to degrade the agent, and then separated from the wash water. The process of caustic washing of the agent-contaminated soils is performed in four washing cycles with caustic solution to achieve a decontamination level of 3X (Section 4.3), a level that indicates that the soil has been surface decontaminated (AMC-R 385-131). The treated soil is placed in the on-post hazardous waste landfill.

The first step in the alternative is to screen the suspected areas for agent-contaminated soils, which is accomplished by drilling and field screening for agent. Agent presence is verified by analysis at the RMA laboratory. The agent-contaminated soils are then excavated and transported to the on-post caustic washing unit as described in Section 4.3.3. The excavated areas are backfilled with fill material obtained from an on-post borrow site. Topsoil obtained off post is placed on the backfilled areas and revegetated with native grasses. The borrow area is also revegetated with native grasses, thereby restoring the habitat value.

The soils are placed in the washing unit and mixed with an 18-percent solution of NaOH at a ratio of 5:1 solution/soil for at least 30 minutes. Two waste streams are generated, the washed soil and the caustic solution. Each of the last three wash cycles require the addition of 15 percent new caustic solution, and an estimated 2,400 lbs of agent degradation products and excess caustic solution is generated for each cubic yard of soil. The spent caustic is evaporated by spray drying, a process consisting of heating the solution with an infrared lamp to remove most of the water, and then completing the drying in an oven at 110°C. The capacity of the unit allows each caustic wash to treat approximately 5.6 BCY of agent-contaminated soils. A total of 7,900 BCY of salts with agent degradation produces and excess NaOH generated from the caustic washing

are transported to the on-post hazardous waste landfill along with the treated soils. The 210 BCY of soils with isolated human health and biota exceedances are excavated and placed in the on-post hazardous waste landfill. A total of 8,600 BCY of salts, treated soils and isolated exceedances are landfilled. The on-post landfill requires 1 year to construct and is fenced to prevent wildlife from entering the area. The landfill undergoes long-term (30-year) maintenance and monitoring after closure.

Table 6.5-3 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs and irreversibly reduces contaminant TMV. The alternative also complies with the Army regulations regarding agent-contaminated materials (AMC-R 385-131). The habitat is improved at the site following revegetation. The removal and treatment of the agent- contaminated soils is anticipated to be completed within 3 years. The total estimated present worth cost of this alternative is $3,800,000. Table B2.2-A3 details the costing for this alternative.

6.5.4 Alternative A4: Incineration/Pyrolysis

Alternative A4: Incineration/Pyrolysis treats 450 BCY of agent-contaminated soils by on-post incineration. This alternative achieves the 5X criterion for materials containing agent as discussed in Section 4.3. Areas with the potential presence of agent are screened using a drilling program to identify soils containing agent. Soil samples collected during drilling are screened by field analytical methods for agent and sent to the RMA laboratory for verification. The soils identified as containing agent are excavated and transported to the rotary kiln incinerator.

The centralized incineration facility is constructed in the northeast corner of Section 2. The facility requires approximately 1 year to build and requires an additional year for testing. The incinerator has a throughput of approximately 470 BCY/day and a total solids residence time of 66 minutes at 760°C. Section 4.5.26 discusses emission controls for incinerator off gases. The 5 BCY of particulates from the scrubber blowdown, which constitute an estimated 1 percent of

the solids feed, are placed in the on-post landfill along with 210 BCY of soils with isolated human health and biota exceedances in this subgroup. The excavations from soils with agent and isolated human health and biota exceedances are backfilled with borrow material obtained from an on-post borrow area. Both the backfill and borrow area are revegetated with native grasses.

Table 6.5-4 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs since all contaminated soils are treated to destroy agent and the soils with isolated human health and biota exceedances are contained. This alternative achieves Army regulations (AMC-R 385-131) regarding agent-contaminated materials. The habitat is improved at the site and is restored at the borrow area. Long-term monitoring and maintenance are required for the landfill. The incineration of 450 BCY of soil requires less than 1 year, but the construction and testing of the facilities requires 2 years before the soils can be treated. The alternative requires 3 years to complete. The estimated present worth cost of this alternative is $2,900,000. Table B2.2-A4 details the costing for this alternative.

6.5.5 Alternative A5: Soil Solvent Washing; Landfill

Alternative A5: Soil Washing (Solvent Washing); Landfill (On-Post Landfill) addresses the 450 BCY of agent-contaminated soils in the Toxic Storage Yards Subgroup through the process of solvent washing in a caustic solvent solution. Solvent washing is a physical/chemical treatment process option in which agent-contaminated soil is excavated, mixed and agitated with organic solvent and sodium hydroxide wash fluids in an aboveground unit to degrade agent, and then separated from the wash solvent. The solvent is recycled and the product solvent and oil containing the contaminants is sent for off-site disposal. The process of solvent washing of the agent-contaminated soils is performed in three washes to achieve an Army decontamination level of 3X (Section 4.3), a level that indicates that the soil has been surface decontaminated (AMC-R 385-131). The treated soil is placed in the on-post hazardous waste landfill.

The first step in the alternative process is to screen the suspected areas for agent-contaminated soils, which is accomplished by drilling and field screening. Agent presence is verified by analysis at the RMA laboratory. The agent-contaminated soils are then excavated and transported to the on-post solvent washing unit as described in Section 4.4.4. Any abandoned utilities encountered during excavation are removed and consolidated with the structural debris. The excavated areas are backfilled with fill material obtained from an on-post borrow area. Topsoil obtained off post is placed on the backfilled areas and is revegetated with native grasses. The borrow area is also revegetated with native grasses, thereby restoring the value of the habitat.

Excavated soils are screened to remove debris and oversized materials. The oversized material is fed to a size reduction unit as described in Section 7.3, then back into the feed stream. Maximum size of the feed material is 1/2 inch in diameter. The feed is then mixed and agitated with refrigerated TEA solvent and sodium hydroxide in a washer/dryer mixer vessel. As the solvent solubilizes the organic contaminants in the waste the agent is hydrolyzed. The soil settles to the bottom of the vessel. The solvent/water mixture is removed and decanted. Decanted TEA is sent to a stripping column where the contaminants are separated from the TEA and the TEA is recycled to the washer/dryer mixing vessel. The water is sent to another stripping column to remove any residual TEA. The product water is later added back to the treated soils to return them to their pretreatment moisture content. Three extractions are necessary to obtain the desired treatment level. The three extractions result in a total residence time of at least 30 minutes. Once treatment is complete, product materials are adjusted back to neutral pH and placed in the on-post landfill. The residual TEA containing the concentrated contaminants is sent for off-post disposal. Less than 450 gallons of residual TEA containing concentrated contaminants is expected to be generated.

The 210 BCY of soils with isolated human health and biota exceedances are excavated and placed in the on-post hazardous waste landfill along with the treated soils. The on-post hazardous waste landfill requires 1 year to construct and is fenced to prevent wildlife from

entering the area. The landfill undergoes long-term (30-year) maintenance and monitoring after closure.

Table 6.5-5 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs and irreversibly reduces contaminant TMV. Although this alternative is expected to comply with the Army regulations regarding agent-contaminated materials, this particular process has not previously been used to treat agent-contaminated material. Treatability studies will assess the ultimate effectiveness of the process. The habitat is improved at the site following revegetation. The removal and treatment of the agent-contaminated soils is anticipated to be completed within 2 years. The total estimated present worth cost of this alternative is $3,200,000. Table B2.1-A3 details the costing for this alternative.

6.6 TOXIC STORAGE YARDS SUBGROUP SELECTION OF PREFERRED ALTERNATIVE

Agent is expected to be found in 450 BCY of soils in sites in the Toxic Storage Yards Subgroup. These sites are suspected to potentially contain agent based on historical usage or the presence of agent breakdown products. Four isolated detections of CLC2A above the Human Health SEC account for 130 BCY of human health exceedance volume. The Biota SEC are exceeded by arsenic in four samples (Table 6.4-2), resulting in 81 BCY of biota exceedance volume.

Sites in this subgroup contain poor- to moderate-quality habitat based on the vegetation present. Areas disturbed by remedial actions are to be revegetated after remediation to restore and improve the habitat. The two sites in this subgroup that are within the Bald Eagle Management Area are considered sensitive habitat, so remedial actions for these sites must be coordinated with the USFWS to ensure that habitat disturbance is minimized.

Selection of the preferred alternative for this subgroup must consider the exposure risks of leaving potential agent contamination in place versus the short-term risk to site workers of

excavation the treatment, and risks to biota in sensitive habitats. Risks to site workers can be minimized with appropriate health and safety equipment and procedures.

Alternative 1: No Additional Action (Provisions of FFA) does not protect human health and is eliminated from further consideration as the preferred alternative since soils potentially contaminated with agent remain in place. The four remaining alternatives achieve RAOs and meet the two DAA threshold criteria—protection of human health and the environment and compliance with action-specific and location-specific ARARs.

Alternative A2: Soil Cover interrupts exposure pathways through containment of contaminated soils. Alternative A5: Soil Washing (Solvent Washing); Landfill exhibits approximately the same cost ($3,200,000) as Alternative A3: Soil Washing (Solution Washing); Landfill ($3,800,000), and both alternatives utilize caustic solutions to degrade agent in soils. The equipment required for solvent/caustic washing is not readily available and is not well demonstrated at full scale. The soil washing technology using a caustic solution and spray dryer, however, is not commercially available for full-scale operation and requires the disposal of 7,900 CY of residual salts. Alternative A4: Incineration/Pyrolysis has the lowest cost of the three treatment alternatives ($2,900,000) and requires disposal of only 5 BCY of particulates and salts from the off-gas treatment system in the on-post landfill.

The preferred alternative for the Toxic Storage Yards Subgroup is Alternative A4: Incineration/Pyrolysis. This alternative exhibits the lowest cost of the protective alternatives. Only a small quantity of residuals are generated by treating agent-contaminated soils through rotary kiln incineration, and the soils with isolated human health and biota exceedances are excavated and contained in the on-post landfill. In addition, Alternative A4: Incineration/Pyrolysis complies with Army regulations regarding the treatment of agent-contaminated materials.

Table 6.0-1 Characteristics of the Agent Storage Medium Group

Characteristic	North Plants Subgroup	Toxic Storage Yards Subgroup
<u>Contaminants of Concern</u>		
Human Health	As	CLC2A
Biota	OCPs, As, Hg	As
<u>Exceedance Area (SY)</u>		
Total	960	140
Human Health	100	70
Biota	860	70
Potential Agent	28,000	270,000
Potential UXO	not applicable	not applicable
<u>Exceedance Volume (BCY)</u>		
Total	610	210
Human Health	67	130
Organic	0	130
Inorganic	67	0
Principal Threat	0	0
Biota	540	81
Potential Agent	63	450
Potential UXO	not applicable	not applicable
<u>Depth of Contamination (ft)</u>		
Human Health	0-1	0-6
Biota	0-2	0-5

Table 6.1-1 Summary of Contaminant Concentrations for the North Plants Subgroup

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC (ppm)
<u>Human Health Exceedance Volume</u>					
Arsenic[2]	4,800	not applicable	530	5,300	16.5
<u>Biota Exceedance Volume</u>					
Dieldrin[2]	3	not applicable	40	400	0.83
Endrin[2]	0.086	not applicable	15	15,000	0.029
Arsenic	74–240	120	530	5,300	16.5
Mercury	1.3–2.9	2.1	470	470,000	0.99

1 Based on concentrations of contaminants of concern above SEC within the exceedance volume.
2 Reported as isolated detections.

Table 6.1-2 Frequency of Detections for North Plants Subgroup

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	71	65	91.5%	6	8.5%	0	0.0%	0	0.0%	0	0.0%
Benzene	40	37	92.5%	3	7.5%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	67	67	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroacetic Acid	43	43	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlorobenzene	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroform	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	68	66	97.1%	2	2.9%	0	0.0%	0	0.0%	0	0.0%
p,p,DDT	69	66	95.7%	3	4.3%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	60	60	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	12	12	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	60	60	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	70	62	88.6%	7	10.0%	1	1.4%	0	0.0%	0	0.0%
Endrin	69	66	95.7%	2	2.9%	1	1.4%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	67	67	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Isodrin	68	66	97.1%	2	2.9%	--	--	0	0.0%	0	0.0%
Methylene Chloride	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	40	39	97.5%	1	2.5%	--	--	0	0.0%	0	0.0%
Toluene	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	69	26	37.7%	34	49.3%	7	10.1%	1	1.4%	1	1.4%
Cadmium	61	50	82.0%	11	18.0%	--	--	0	0.0%	0	0.0%
Chromium	69	0	0.0%	69	100.0%	--	--	0	0.0%	0	0.0%
Lead	67	19	28.4%	48	71.6%	--	--	0	0.0%	0	0.0%
Mercury	65	43	66.2%	20	30.8%	2	3.1%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.

Table 6.2-1 Evaluation of Alternative A1: No Additional Action (Provisions of FFA) for the North Plants Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Does not achieve Human Health or Biota RAOs as soils with potential agent and isolated human health and biota exceedances remain if controls are not implemented; potential groundwater impacts not reduced.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs as long-term monitoring and site reviews achieved.*
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as North Plants Subgroup not located in 100-year floodplain or wetlands.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Small anticipated volume of soils with agent (63 BCY); low levels of isolated human health and biota exceedances (OCPs, As and Hg).
b) Adequacy and reliability of controls	b) No controls implemented. Site reviews and groundwater monitoring required.
c) Habitat impacts	c) Habitat quality not improved. Existing poor-quality habitat not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction of contaminant volume or mobility; 28,000 SY of soils with potential agent remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative. Soils with potential agent and isolated human health and biota exceedances remain.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or vapor emissions.
c) Environmental impacts of remedial actions	c) Minimal environmental impact. Existing poor-quality habitat not impacted by remedial alternative; migration of contaminants to groundwater not reduced.
d) Time until RAOs are achieved	d) RAOs not achieved. Soils with potential agent and isolated human health and biota exceedances remain on site.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) No services required for monitoring, except for site reviews.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $180,000
d) Total	d) $180,000

Table 6.2-2 Evaluation of Alternative A2: Caps/Covers (Soil Cover) for the North Plants Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; soils with potential agent and isolated human health and biota exceedances contained by soil cover preventing human and biota exposure; potential groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technolody Description Document, Appendix A, Tables A-1, A-5, and A-17)	a) Complies with action-specific ARARs regarding construction of soil cover layers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as North Plants Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 28.000 SY of soils with potential agent contained through installation of 28,000-SY soil cover.
b) Adequacy and reliability of controls	b) Adequate controls. Site reviews required for soil cover; erosion control and vegetative cover maintenance required; high confidence in engineering controls of soil cover.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat; removal of burrowing animals help preserve integrity of cover and prevent exposure.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Human and biota exposure pathways interrupted and mobility of contaminants reduced through installation of 28,000-SY soil cover.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Reduction in mobility reduction and hazards reversible if cover degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during cover installation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impact. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 1 year. Installation of 28,000 SY soil cover feasible within 1 year.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably maintained thereafter; additional remedial actions easily undertaken for soils left in place, although cover adds to overall site volume; demolition of structures required, but structural debris can be placed under cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of soil cover design and construction regulations.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment readily available for cover construction; soil covers well demonstrated at full scale.

Table 6.2-2 Evaluation of Alternative A2: Caps/Covers (Soil Cover) for the North Plants Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $620,000
c) Long-term	c) $470,000
d) Total	d) $1,010,000

Table 6.2-3 Evaluation of Alternative A3: Soil Washing (Solution Washing); Landfill (On-Post Landfill) for the North Plants Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment and containment; contaminated soils treated to remove agent and contained in on-post landfill, preventing exposure; isolated human health and biota exceedances landfilled; potential groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-17, and A-23)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill design and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as North Plants Subgroup, soil washing facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) for agent demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 63 BCY treated by soil washing and landfilled: 610 BCY of untreated soils contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat at site but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 63 BCY treated by soil washing to remove agent and landfilled; exposure pathways interrupted through containment of 670 BCY in on-post landfill.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) TMV reduction by soil washing irreversible; mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) 1,100 BCY of salts from soil washing landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent screening, excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 2 years. Soil washing of 63 BCY feasible within 2 years; landfilling of 1,800 BCY of soils and salts feasible within 1 year after 1 year for construction of landfill.

Table 6.2-3 Evaluation of Alternative A3: Soil Washing (Solution Washing); Landfill (On-Post Landfill) for the North Plants Subgroup

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; demolition of structures and removal of structural debris required; landfill cells monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of direct treatment unit and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Available. Limited vendor sources available for soil washing unit; equipment, specialists, and materials readily available for construction of landfill; landfills well demonstrated at full scale; soil washing using caustics and spray drying not well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $73,000
b) Operating	b) $390,000
c) Long-term	c) $7,000
d) Total	d) $460,000

Table 6.2-4 Evaluation of Alternative A4: Incineration/Pyrolysis (Rotary Kiln) for the North Plants Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to agent detection levels; blowdown solids placed in on-post landfill; isolated human health and biota exceedances landfilled; potential groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs	b) Complies with location-specific ARARs as North Plants Subgroup, incinerator, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) agent demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 63 BCY of soils with agent demilitarized on post and backfilled; approximately 1% of solids feed recovered from off-gas treatment equipment placed in on-post landfill; 610 BCY of untreated soils contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat at site but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 63 BCY of soils with agent demilitarized on-post by incineration; exposure pathways interrupted through containment of 610 BCY in on-post landfill.
b) Degree and quantity of TMV reduction	b) Agent reduced to below detection levels (>99.99% destruction removal efficiency); TMV of OCPs eliminated; scrubber blowdown solids from off-gas treatment equipment with salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by incineration irreversible.
d) Type and quantity of treatment residuals	d) 1 BCY of blowdown solids with salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent clearance, excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation; vapor emissions associated with incinerator controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 3 years. Demilitarization of 63 BCY feasible within 1 year after 2 years for construction of incineration facility; containment of 610 BCY feasible within 1 year after 1 year for construction of landfill.

Table 6.2-4 Evaluation of Alternative A4: Incineration/Pyrolysis (Rotary Kiln) for the North Plants Subgroup

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required timeframe and reliably operated and maintained thereafter; landfill cells monitored; demolition of structures and removal of structural debris required, additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of incineration and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of incinerator; equipment, specialists, and materials readily available for construction of landfill; incinerators and landfills well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $16,000
b) Operating	b) $340,000
c) Long-term	c) $2,000
d) Total	d) $360,000

Table 6.2-5 Evaluation of Alternative A5: Soil Washing (Solvent Washing); Landfill (On-Post Landfill) for the North Plants Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment and containment; contaminated soils treated to remove agent and contained in on-post landfill, preventing exposure; isolated human health and biota exceedances landfilled; potential groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-17, and A-23)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill design and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as North Plants Subgroup, soil washing facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) for agent demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 63 BCY treated by soil solvent washing and landfilled; 610 BCY of untreated soil contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat at site but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 63 BCY treated by soil washing to remove agent and landfilled; exposure pathways interrupted through containment of 670 BCY in on-post landfill.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) TMV reduction by soil washing irreversible; mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) 670 BCY of treated soils from solvent washing and isolated human health and biota exceedances landfilled. Less than 63 gallons of contaminated liquid sent off-post for treatment.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent screening, excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 2 years. Solvent washing of 63 BCY feasible within 2 years; landfilling of 670 BCY of soils and salts feasible within 1 year after 1 year for construction of landfill.

Table 6.2-5 Evaluation of Alternative A5: Soil Washing (Solvent Washing); Landfill (On-Post Landfill) for the North Plants Subgroup

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible although treatability studies will be required to confirm the effectiveness of the technology for agent treatment. Vendor equipment durability at high pH may also be a problem. Alternative constructed within required time frame; demolition of structures and removal of structural debris required; landfill cells monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of direct treatment unit and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Available. One vendor available for solvent washing unit; equipment, specialists, and materials readily available for construction of landfill; landfills well demonstrated at full scale; solvent washing not well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $53,000
b) Operating	b) $370,000
c) Long-term	c) $3,000
d) Total	d) $430,000

Table 6.4-1 Summary of Contaminant Concentrations for the Toxic Storage Yards Subgroup

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC (ppm)
Human Health Exceedance Volume					
CLC2A	120–130	120	74	74,000	not applicable
Biota Exceedance Volume					
Arsenic	75–270	140	530	5,300	16.5

[1] Based on concentrations of contaminants of concern above SEC within exceedance volume.
CLC2A Chloroacetic Acid
ppm Parts Per Million
SEC Site Evaluation Criteria
– Not Applicable

Table 6.4-2 Frequency of Detections for Toxic Storage Yards Subgroup

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	231	230	99.6%	1	0.4%	0	0.0%	0	0.0%	0	0.0%
Benzene	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	231	231	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroacetic Acid	111	106	95.5%	1	0.9%	--	--	4	3.6%	0	0.0%
Chlorobenzene	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroform	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	231	231	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
p,p,DDT	231	231	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	234	234	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	231	231	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	231	229	99.1%	2	0.9%	0	0.0%	0	0.0%	0	0.0%
Endrin	231	230	99.6%	1	0.4%	0	0.0%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	231	231	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Isodrin	231	231	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Methylene Chloride	40	36	90.0%	4	10.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	40	39	97.5%	1	2.5%	--	--	0	0.0%	0	0.0%
Toluene	40	38	95.0%	2	5.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	40	39	97.5%	1	2.5%	--	--	0	0.0%	0	0.0%
Arsenic	193	129	66.8%	58	30.1%	6	3.1%	0	0.0%	0	0.0%
Cadmium	197	190	96.4%	7	3.6%	--	--	0	0.0%	0	0.0%
Chromium	197	10	5.1%	186	94.4%	--	--	1	0.5%	0	0.0%
Lead	197	73	37.1%	124	62.9%	--	--	0	0.0%	0	0.0%
Mercury	170	169	99.4%	1	0.6%	0	0.0%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.

Table 6.5-1 Evaluation of Alternative A1: No Additional Action (Provisions of FFA) for the Toxic Storage Yards Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Does not achieve Human Health or Biota RAOs as soils with potential agent and isolated human health and biota exceedances remain if controls are not implemented; no unacceptable cross-media or short-term impacts.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Compliance with action-specific ARARs as long-term monitoring and site reviews achieved.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Toxic Storage Yards Subgroup not located in 100-year floodplain or wetlands.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Small anticipated volume of soils with agent (450 BCY) and low levels of isolated human health and biota exceedances (As and CLC2A).
b) Adequacy and reliability of controls	b) No controls implemented. Site reviews required.
c) Habitat impacts	c) Habitat quality not improved. Existing poor-quality habitat not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction of contaminant volume or mobility; 270,000 SY of soils with potential agent remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative. Soils with potential agent and isolated biota and human health exceedances remain.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or vapor emissions.
c) Environmental impacts of remedial actions	c) Minimal environmental impact. Existing poor-quality habitat not impacted by remedial alternative.
d) Time until RAOs are achieved	d) RAOs not achieved. Soils with potential agent and isolated human health and biota exceedances remain on site.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) No services required for monitoring, except for site reviews.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $180,000
d) Total	d) $180,000

Table 6.5-2 Evaluation of Alternative A2: Caps/Covers (Soil Cover) for the Toxic Storage Yards Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; soils with potential agent and isolated human health and biota exceedances contained by soil cover, preventing exposure; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-5, and A-17)	a) Compliance with action-specific ARARs regarding construction of soil cover layers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Compliance with location-specific ARARs as Toxic Storage Yards Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 270,000 SY of soils with potential agent contained through installation of 270,000-SY soil cover.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for soil cover; erosion control and vegetative cover maintenance required; high confidence in engineering controls of soil cover.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat; removal of burrowing animals help preserve integrity of cover and prevent exposure.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Human and biota exposure pathways interrupted and mobility of contaminants reduced through installation of 270,000-SY soil cover.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Reduction in exposure pathways and hazards reversible if cover degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during cover installation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impact. Minimal impact to biota due to existing poor-quality habitat.
d) Time until RAOs are achieved	d) 1 year. Installation of 270,000-SY soil cover feasible within 1 year.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably maintained thereafter; additional remedial actions easily undertaken for soils left in place, although cover adds to overall site volume.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of soil cover design and construction regulations.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment readily available for cover construction; soil covers well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $6,200,000
c) Long-term	c) $2,900,000
d) Total	d) $9,100,000

Table 6.5-3 Evaluation of Alternative A3: Soil Washing (Solution Washing); Landfill (On-Post Landfill) for the Toxic Storage Yards Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment and containment; contaminated soils treated to remove agent and contained in on-post landfill, preventing exposure; isolated human health and biota exceedances landfilled; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-17, and A-23)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill design and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Toxic Storage Yards Subgroup, soil washing facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding agent demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 450 BCY treated by soil washing and landfilled; 210 BCY of untreated soils contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 450 BCY treated by soil washing to remove agent and landfilled; exposure pathways interrupted and mobility of contaminants reduced through containment of 210 BCY of soils in on-post landfill.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) TMV reduction by soil washing irreversible; mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) 7,900 BCY of salts from soil washing landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent screening, excavation, transportation, treatment, and disposal.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat.
d) Time until RAOs are achieved	d) 3 years. Soil washing of 450 BCY feasible within 3 years; containment of 8,600 BCY of soils and salts feasible within 1 year after 1 year for construction of landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; landfill cells monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of soil washing unit and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Available. Limited vendor sources available for soil washing unit; materials, specialists, and equipment readily available for construction of landfill; landfills well demonstrated at full scale; soil washing using caustics and spray drying not well demonstrated at full scale.

Table 6.5-3 Evaluation of Alternative A3: Soil Washing (Solution Washing); Landfill (On-Post Landfill) for the Toxic Storage Yards Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $440,000
b) Operating	b) $3,300,000
c) Long-term	c) $35,000
d) Total	d) $3,800,000

Table 6.5-4 Evaluation of Alternative A4: Incineration/Pyrolysis (Rotary Kiln) for the Toxic Storage Yards Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to agent detection levels; blowdown solids placed in on-post landfill; isolated human health and biota exceedances landfilled; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-10, and A-17)	a) Complies with action-specific ARARs including state regulation on air emissions sources and landfill design and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Toxic Storage Yards Subgroup, incinerator, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding agent demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk meets PRGs. 450 BCY of soils with agent demilitarized on post and backfilled; approximately 1% of solids feed recovered from off-gas treatment equipment placed in on-post landfill; 210 BCY of untreated soils contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat at site but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 450 BCY of soils with agent demilitarized on post by incineration; exposure pathways interrupted through containment of 210 BCY of soils in on-post landfill.
b) Degree and quantity of TMV reduction	b) Agent reduced to below detection levels (>99.99% destruction removal efficiency); TMV of agent eliminated; scrubber blowdown solids from off-gas treatment equipment with salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by incineration irreversible.
d) Type and quantity of treatment residuals	d) 5 BCY of blowdown solids with salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent screening, excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation; vapor emissions associated with incinerator controlled by air emissions control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat.
d) Time until RAOs are achieved	d) 3 years. Demilitarization of 450 BCY feasible within 1 year after 2 years for construction of incineration facility; containment of 210 BCY feasible within 1 year after 1 year for construction of landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; landfill cells monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of incineration and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of incinerator; equipment, specialists, and materials readily available for construction of landfill; incinerators and landfills well demonstrated at full scale.

Table 6.5-4 Evaluation of Alternative A4: Incineration/Pyrolysis (Rotary Kiln) for the Toxic Storage Yards Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $34,000
b) Operating	b) $2,900,000
c) Long-term	b) $1,000
d) Total	c) $2,900,000

Table 6.5-5 Evaluation of Alternative A5: Soil Washing (Solvent Washing); Landfill (On-Post Landfill) for the Toxic Storage Yards Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment and containment; contaminated soils treated to remove agent and contained in on-post landfill, preventing exposure; isolated human health and biota exceedances landfilled; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-17, and A-23)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill design and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Toxic Storage Yards Subgroup, soil washing facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding agent demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 450 BCY treated by solvent washing and landfilled; 210 BCY of untreated soil contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 450 BCY treated by soil washing to remove agent and landfilled; exposure pathways interrupted and mobility of contaminants reduced through containment of 210 BCY of soils in on-post landfill.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) TMV reduction by soil washing irreversible; mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) 660 BCY of treated soils from solvent washing and isolated human health and biota exceedances landfilled. Less than 450 gallons of contaminated liquids sent off-site for disposal.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent screening, excavation, transportation, treatment, and disposal.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat.
d) Time until RAOs are achieved	d) 3 years. Soil washing of 450 BCY feasible within 3 years; containment of 660 BCY of soils and feasible within 1 year after 1 year for construction of landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible although treatability studies will be required to confirm the effectiveness of the technology for agent treatment; vendor equipment durability at high pH may also be a problem; alternative constructed within required time frame; landfill cells monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of solvent washing unit and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Available. Limited vendor sources available for solvent washing unit; materials, specialists, and equipment readily available for construction of landfill; landfills well demonstrated at full scale; solvent washing not well demonstrated at full scale.

Table 6.5-5 Evaluation of Alternative A5: Soil Washing (Solvent Washing); Landfill (On-Post Landfill) for the Toxic Storage Yards Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $39,000
b) Operating	b) $3,200,000
c) Long-term	c) $3,000
d) Total	d) $3,200,000

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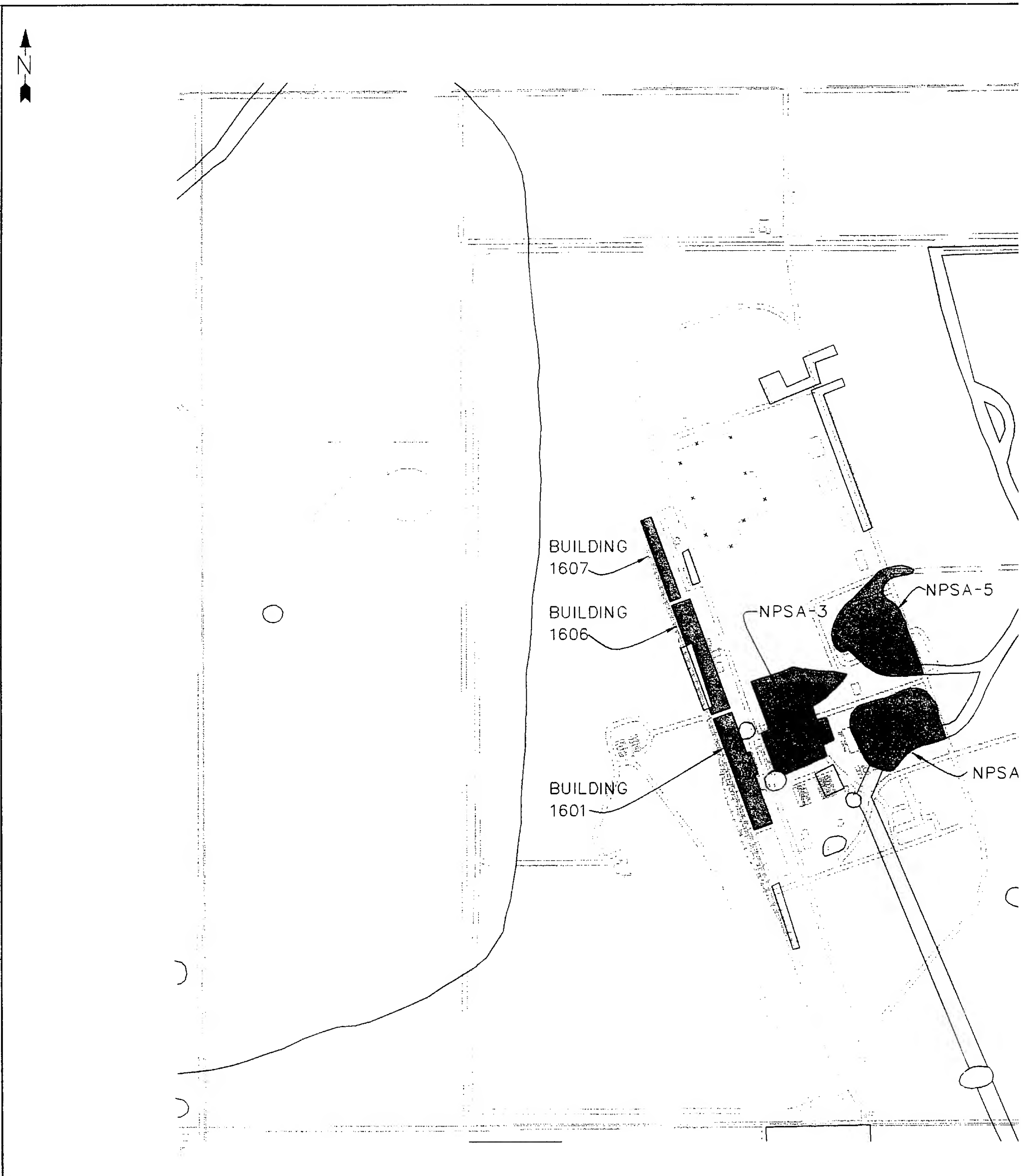

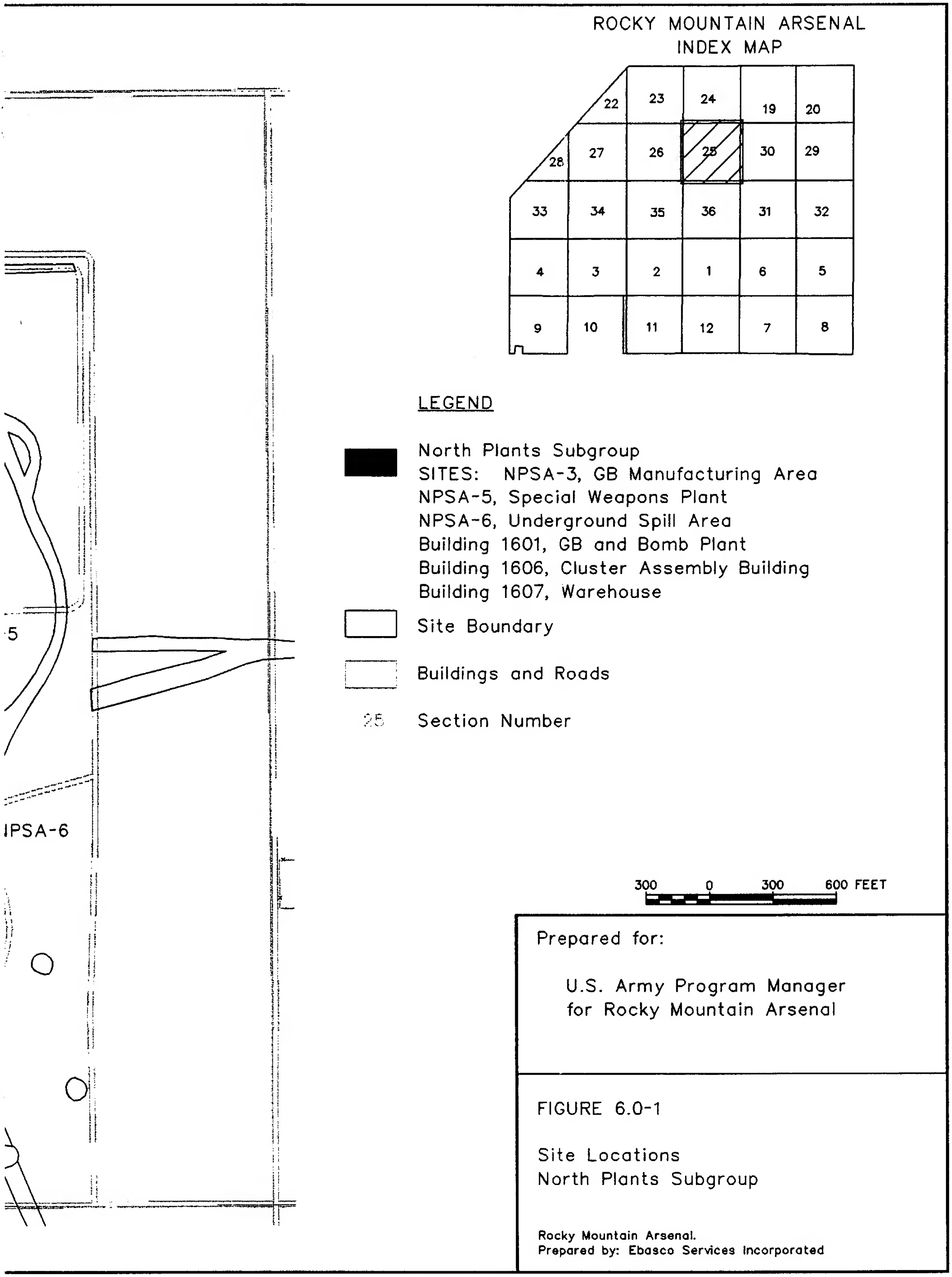

FIGURE 6.0-1

Site Locations
North Plants Subgroup

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated

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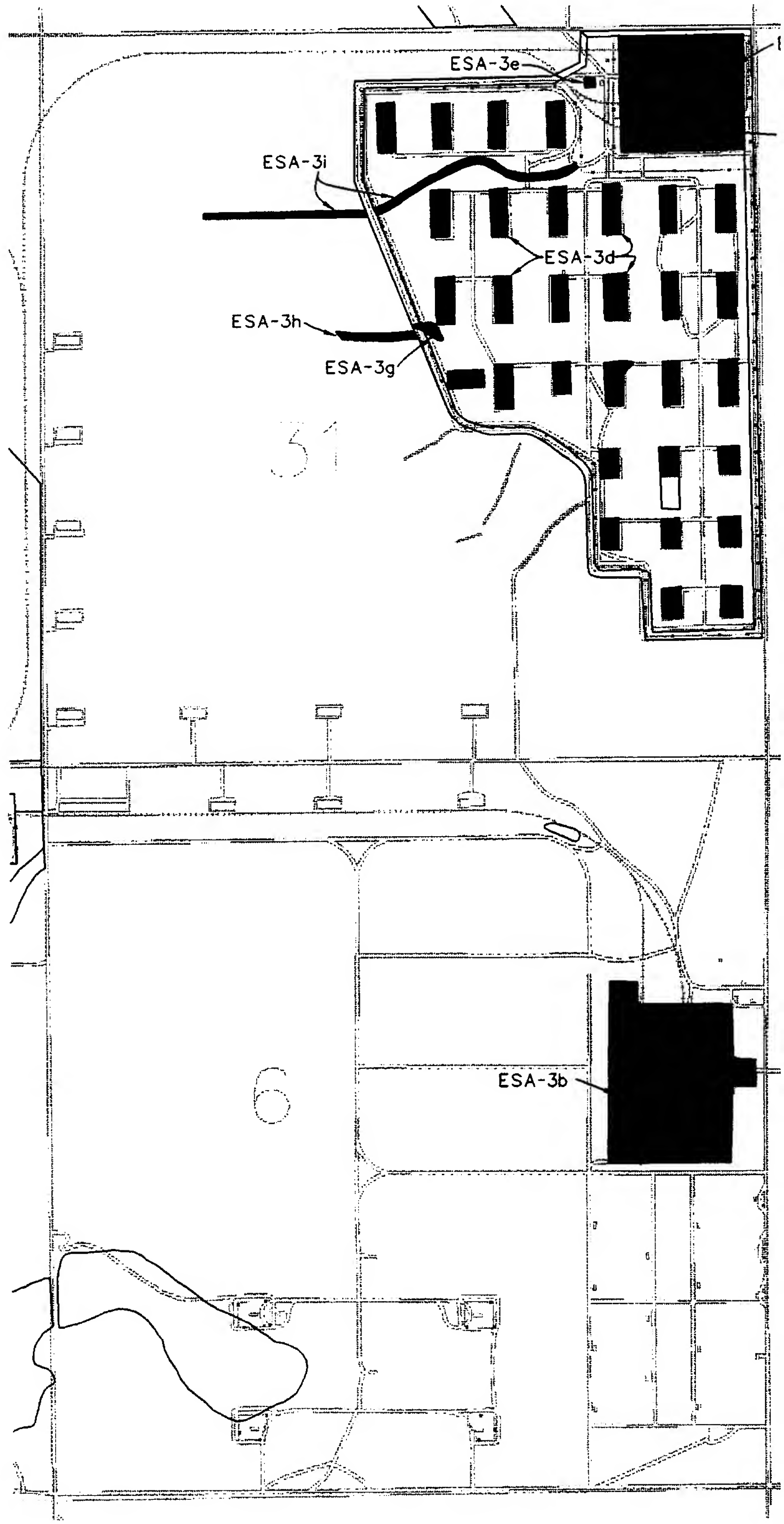

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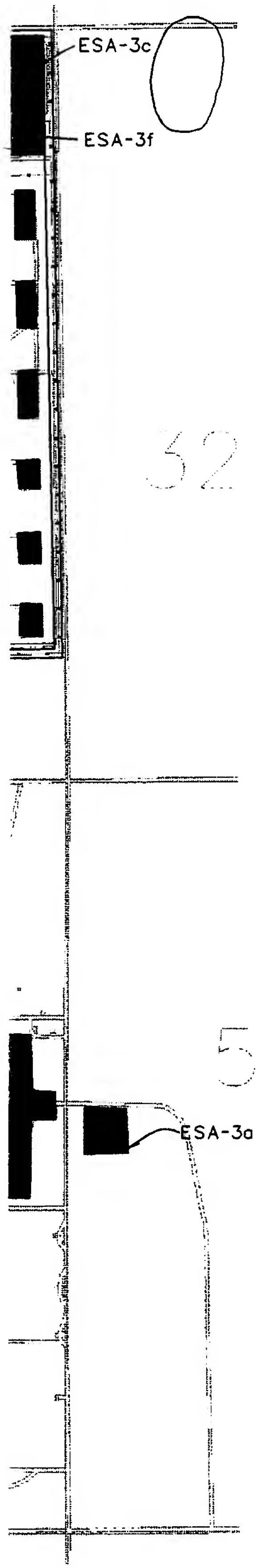
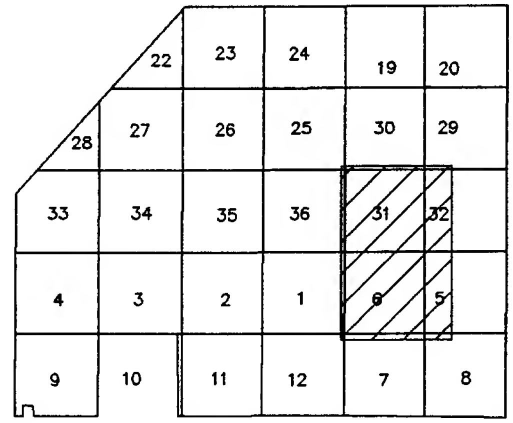


ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Toxic Storage Yards Subgroup
SITES: ESA-3a, Section 5 Storage Yard
ESA-3b, Section 6 Old Storage Yard
ESA-3c, Section 31 New Storage Yard
ESA-3d, Section 31 Toxic Yard Plots
ESA-3e, VX Demilitarization Pad
ESA-3f, Rail Loading Area
ESA-3g, Open Storage Area
ESA-3h, Open Storage Area Ditch
ESA-3i, Toxic Storage Plots Ditch

Site Boundary

Buildings and Roads

31 Section Number

540 0 540 1080 FEET

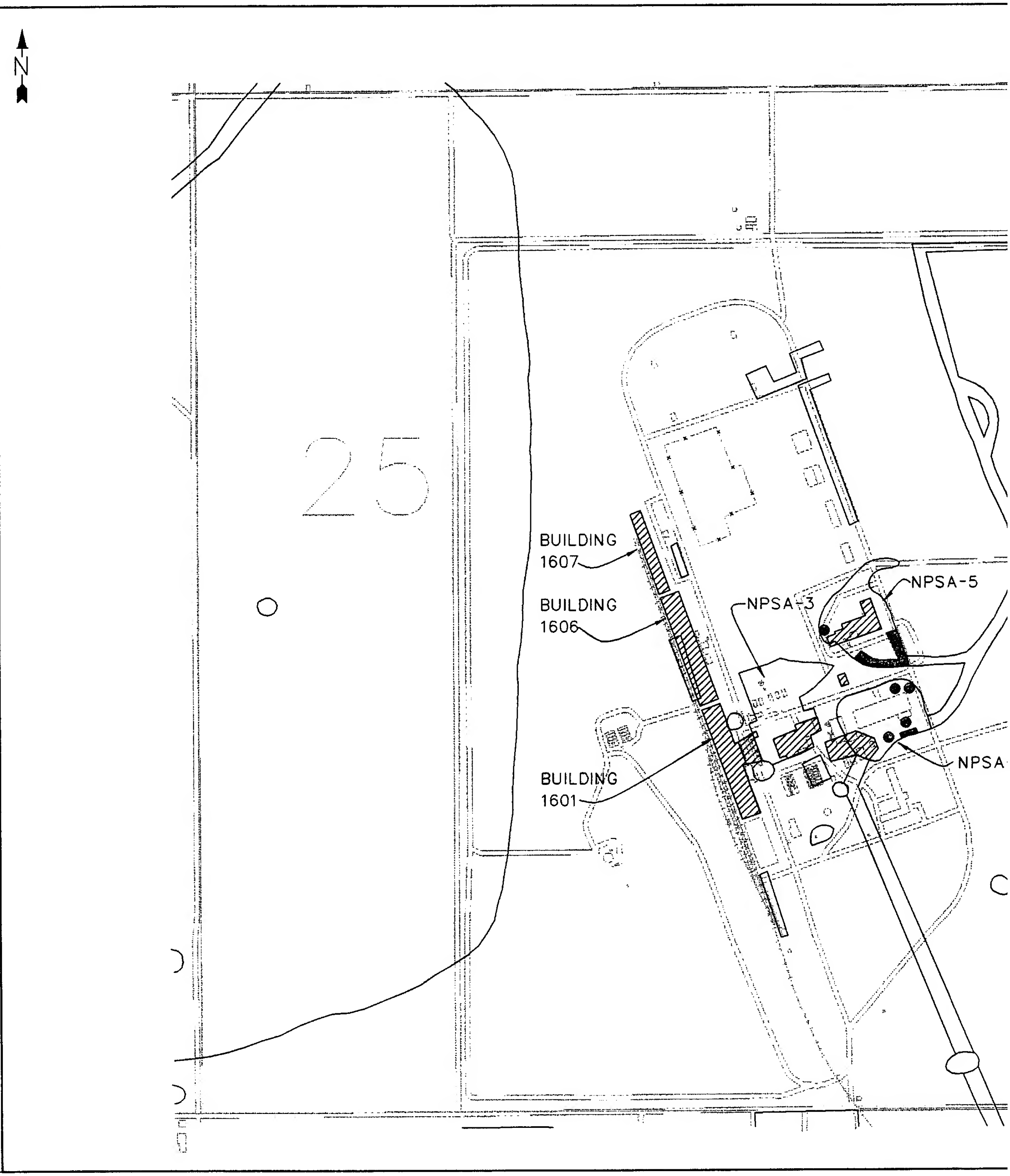
Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 6.0-2

Site Locations
Toxic Storage Yards Subgroup

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated



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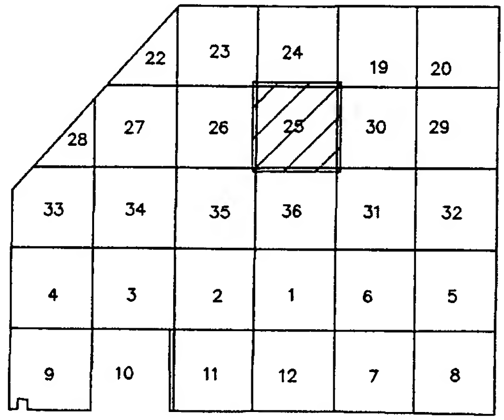
ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Potential Agent Presence Area

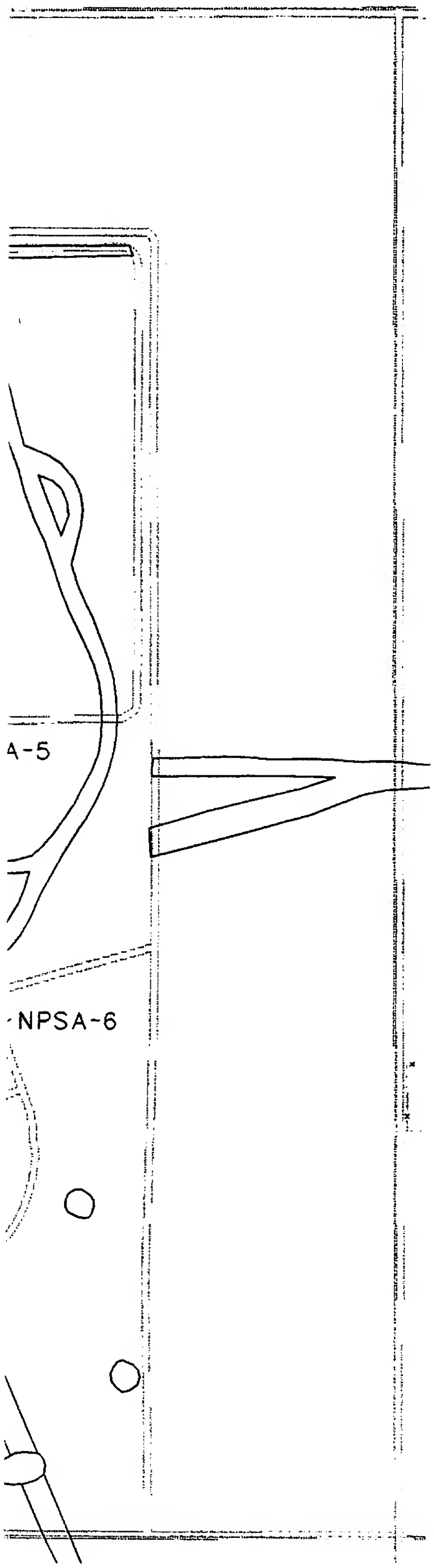
Biota Exceedance Area

Human Health Exceedance Area

Site Boundary

Buildings and Roads

25 Section Number



300 0 300 600 FEET

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FIGURE 6.1-1

Exceedance Areas
North Plants Subgroup

Rocky Mountain Arsenal.
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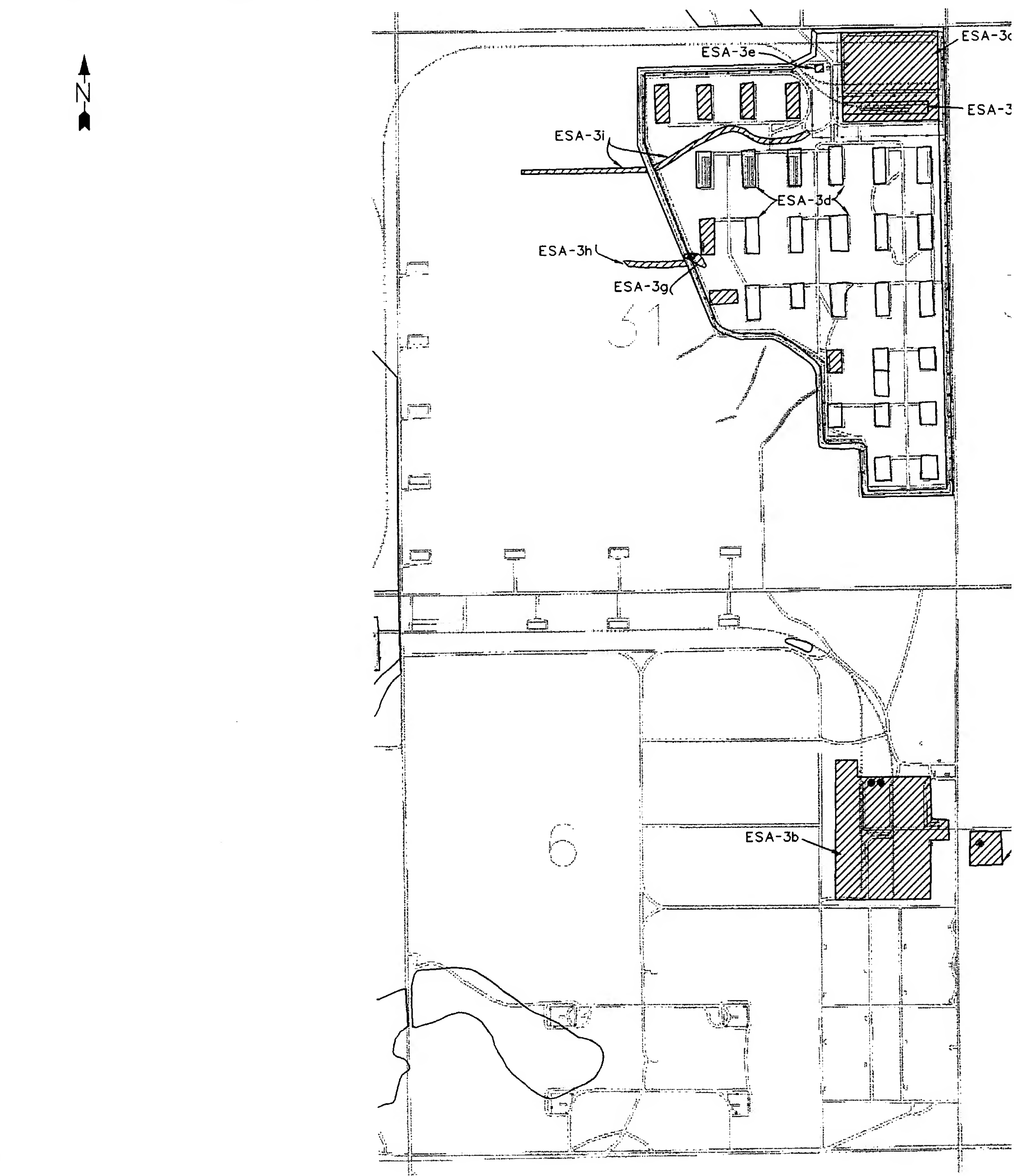
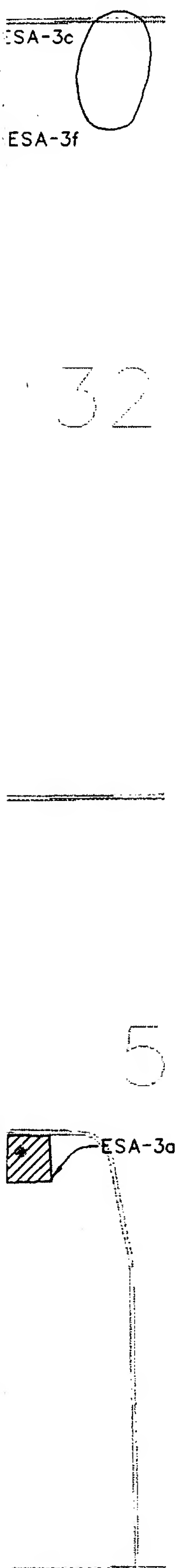
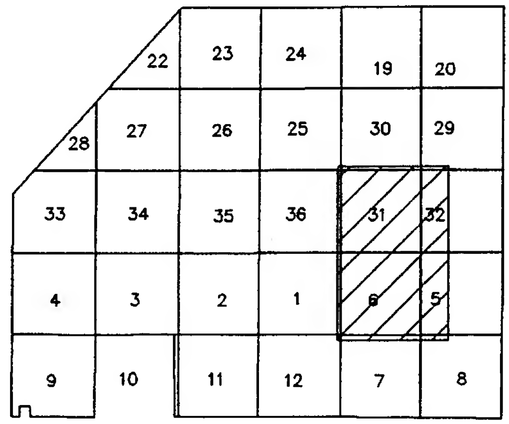


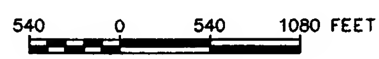


ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

- Potential Agent Presence Area
- Biota Exceedance Area
- Human Health Exceedance Area
- Site Boundary
- Buildings and Roads
- 31 Section Number



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for Rocky Mountain Arsenal

FIGURE 6.4-1

Exceedance Areas
Toxic Storage Yards Subgroup

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated

7.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE LAKE SEDIMENTS MEDIUM GROUP

The Lake Sediments Medium Group includes four lakes located in the southern portion of RMA and sediments from the North Bog (Figure 7.0-1). These sites were grouped together based on the potential risk they present to aquatic biota. Isolated exceedances of Human Health SEC also occur in the sediments of Upper and Lower Derby Lakes and Havana/Peoria Street Ponds. Contamination in this medium group has resulted from the influx of contaminants transported to the lakes and North Bog by groundwater or surface water.

The COCs exceeding the Biota SEC in this medium group are mainly OCPs, with some mercury. The concentrations of these COCs are below the certified reporting limits (CRLs) or the Biota SEC in the majority of the samples collected. Human health exceedances of chlordane and chromium were also detected, but only at isolated locations near the inlets of the lakes. Sites within this medium group are also potential sources of groundwater and surface-water contamination based upon the direct contact of contaminated sediments with groundwater and surface water (EBASCO 1992a/RIC 92017R01). Table 7.0-1 presents the characteristics of this medium group, including exceedance volumes and COCs.

In the DSA, alternatives were developed and screened based on the general characteristics of the medium group. In the DAA, individual subgroups were not developed for the five sites, so the retained alternatives apply to the Lake Sediments Medium Group as a whole. The characteristics of the sites in this group—including contaminant types and contaminant concentrations, site configuration, and depth of contamination—were evaluated to determine whether any changes to the range of alternatives retained in the DSA were appropriate. The modifications that were made to the retained alternatives consist of adding specific technologies to remove the higher levels of contamination that exceed Human Health SEC from the inlets of the lakes.

The following sections present the characteristics of the medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection

of a preferred alternative based on a comparative analysis of the alternatives. The preferred alternative is as follows:

- Alternative B1a—Excavation of the human health exceedance volumes and consolidation in Basin A as grading fill prior to the installation of a cap at Basin A. Continued monitoring and 5-year site reviews initiated for the remainder of the sediments.

7.1 MEDIUM GROUP CHARACTERISTICS

The Lake Sediments Medium Group is composed of sites NCSA-7 (North Bog), SSA-1b (Upper Derby Lake), SSA-1c (Lower Derby Lake), SSA-1e (Lake Ladora), and SSA-5b (Havana/Peoria Street Ponds) (Figure 7.0-1). These sites contain sediments contaminated by the influx of suspended solid- or dissolved-phase contaminants transported to the lakes by groundwater or surface water. The water from Upper and Lower Derby Lakes and Lake Ladora was formerly used as process/coolant water for South Plants.

Table 7.1-1 provides a summary of contaminants, concentrations within the exceedance volume, and the corresponding exceedance values for the medium group. Table 7.1-2 summarizes the frequency of detections for samples taken at sites within the medium group. As shown by these tables, only a single isolated detection of chromium at 150 ppm and three isolated detections of chlordane generating an average exceedance concentration of 23 ppm are above the Human Health SEC. The isolated detection of chromium was found in SSA-1c; however, this isolated exceedance is located beneath more than 10 ft of water, thereby interrupting the exposure pathway for humans. Within the biota exceedance volumes the Biota SEC is exceeded by mercury (0.71 ppm on average) and OCPs (including an average concentration of 0.83 ppm for aldrin and 0.3 ppm for dieldrin). The frequency of detections above the Biota SEC is less than 3 percent for all contaminant samples. Biota COCs were found between 0 and 8 ft below the soil surface; however, the majority of the exceedances were found between the 0- and 3-ft depth interval. Site SSA-1b contains the maximum COC concentrations.

Figure 7.1-1 presents locations of the biota and human health exceedance areas. Approximately 52,000 BCY of contaminated soils are contained in the isolated human health exceedance areas.

Although these areas were determined to be human health exceedance areas based on elevated levels of chlordane, the areas also contain the highest levels of most Biota COCs. The biota exceedance area for the Lake Sediments Medium Group is 340,000 SY (Table 7.0-1). Appendix A presents the exceedance volume and area calculations.

Sites in this group represent a potential source of groundwater and surface-water contamination due to the proximity of the contaminated sediments to both aqueous media. However, groundwater plumes have not been identified as originating from these sites.

The sites in the Lake Sediments Medium Group provide high-quality aquatic and wetland habitat with relatively low levels of sediment contamination and no detectable surface-water contamination. With the exception of site NCSA-7, the sites are also located within the Bald Eagle Management Area. Therefore, the evaluation of alternatives for this medium group must consider the impacts of alternatives on the habitat within these sites. The areas disturbed during remedial actions are to be restored to the existing high-quality habitat, but only over the course of several years. If dredging of the lake sediments is included as part of the remedial alternative, the activity is spread out over 4 years to reduce the impact on habitat.

7.2 EVALUATION OF ALTERNATIVES

The five alternatives for the Lake Sediments Medium Group vary in approach from no action to containment and treatment. For this medium group, the major modification to the retained DSA alternatives is the addition of specific technologies to address the isolated human health exceedances. Based on the both low levels of contamination in the human health exceedance areas compared to other sites at RMA, and the relatively high level of contamination compared to the remaining lake sediments, the technology of consolidating the human health exceedances from the lakes into Basin A as grading fill was developed as discussed in Section 7.2-2. Alternative B1a: Caps/Covers (Clay/Soil Cap) with Consolidation; No Additional Action (Provisions of FFA) was added and Alternative B10: Caps/Covers (Clay/Soil Cap) with

Consolidation; In Situ Biological Treatment (Aerobic Biodegradation) was modified to address the human health exceedance areas in the lakes by excavation, consolidation, and containment.

The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA.

7.2.1 Alternative B1: No Additional Action

Alternative B1: No Additional Action (Provisions of FFA) applies to 340,000 SY of soils in the Lake Sediments Medium Group. Biota and isolated human health exceedances of 370,000 BCY remain in place, and no action is taken to reduce biota exposure or interrupt potential pathways for groundwater and surface-water contamination at sites in this medium group. Long-term monitoring of untreated sediments is conducted (an average of 35 samples per year) and 5-year reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Table 7.2-1 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative does not achieve Human Health and Biota RAOs in the short term because controls are not initiated and contaminated sediments remain in place. Natural attenuation of this contamination is ongoing, but the estimated time frame to achieve PRGs is longer than 30 years. The residual risk to biota is low due to the relatively low levels of contamination found in the sediments. Migration of contaminants from the sediments to surface water and groundwater is not reduced. Groundwater and surface water monitoring are required. The high-quality habitat in these sites is not disturbed. The total estimated present worth cost for this alternative is $2,200,000. Table B3.1-B1 presents the detailed costing for this alternative.

7.2.2 Alternative B1a: Caps/Covers with Consolidation; No Additional Action

Alternative B1a: Caps/Covers (Clay/Soil Cap) with Consolidation; No Additional Action (Provisions of FFA) addresses exceedance soils in the Lake Sediments Medium Group in two ways. The organic human health exceedance volume of 51,000 BCY contains the highest levels

of contamination in the lake sediments. These exceedances, which are near the inlets to the lakes, are grubbed and cleared of aquatic vegetation and then excavated using a backhoe. Prior to excavation, 2,500 linear ft of temporary cutoff walls are installed to a depth of 5 ft to prevent sediments suspended in the inlets from flowing into the lakes. The contaminated sediments are then excavated, dewatered, transported to Basin A, consolidated as grading fill over the more highly contaminated soil present in the basin, and contained with a clay/soil cap. The excavation is backfilled with topsoil to facilitate restoration of the wetlands. Backfilled areas are further restored by planting wetland vegetation. As discussed in Section 10.2.3, the containment of Basin A requires between 1,200,000 and 1,800,000 BCY of grading fill to achieve design grades for capping. Consolidation of 51,000 BCY of organic human health exceedances from the Lake Sediments Medium Group removes the highest levels of contamination from the lakes and helps meet the need for grading fill in Basin A. The biota exceedance volume of 310,000 BCY is left in place under the no-action part of the alternative. This area is monitored over the long term (an average of 35 samples per year) and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Table 7.2-2 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. The alternative is protective of human health through removal and containment of human health exceedances in Basin A. Biota RAOs are not achieved in the short term because sediments in exceedance of Biota SEC remain in place. However, the residual risk to biota is low due to the relatively low levels of contamination left in the sediments. Natural attenuation is ongoing, but the estimated time frame to achieve PRGs is longer than 30 years. Excavation of only the human health exceedances minimizes adverse impacts on the high-quality habitat present in the Lake Sediments Medium Group and reduces, but does not eliminate, the migration of contaminants to surface water and groundwater. Selection of this alternative is predicated on the selection of Alternative 6f for Basin A. The total estimated present worth cost of this alternative is $5,700,000. Table B3.1-B1a presents the details of costing for this alternative.

7.2.3 Alternative B3: Landfill

Alternative B3: Landfill (On-Post Landfill) consists of dredging and excavating the biota and isolated human health exceedances of 370,000 BCY from the Lake Sediments Medium Group and placing the sediments in an on-post landfill. After the area is grubbed and cleared of vegetation, the 51,000 BCY of the more highly contaminated sediments in the lake inlets are excavated using a backhoe and then disposed in the landfill. Prior to clearing and excavation, 2,500 linear ft of temporary cutoff walls are installed to a depth of 5 ft to prevent the more highly contaminated inlet sediments from moving into the lakes. The excavated area is backfilled with topsoil and revegetated with wetland species. The 310,000 BCY of contaminated sediments from the lakes are then dredged. The dredged sediments are pumped to a lined settling basin to reduce the moisture content prior to landfilling. Liquid from the settling basin is pumped back to the lakes and could resuspend contaminants in the water. Each year approximately 100,000 BCY of sediments are removed from the lakes and dried for a period of nearly 1 year in the settling basin. In this manner, the dredging is accomplished over a period of 4 years to minimize the impacts of dredging on the lake systems. Dried sediments are transported to the landfill for containment. The landfill facility contains multiple cells and requires 1 year for the construction of the first cell and associated support facilities. Fences are installed to exclude biota. Containment of untreated sediments in the landfill requires leachate collection and treatment, groundwater monitoring, and long-term maintenance of the landfill cover.

Table 7.2-3 details the evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs and PRGs and reduces the migration of contaminants to surface water and groundwater since the contaminated soils are excavated and transferred to a containment cell. This requires approximately 6 years, based on the 1-year construction time for the landfill cell and the 5 years required for excavating the inlets and dredging and drying the lake sediments. The high-quality habitat of the lakes is restored following completion of the alternative but, during remediation, dredging destroys 340,000 SY of aquatic habitat and adversely impacts the remaining aquatic habitat within the lakes. In addition, construction of a settling basin temporarily impacts terrestrial habitat. Therefore, habitat mitigation is required to offset these

losses. The total estimated present worth cost of this alternative is $24,000,000. Table B3.1-B3 details the costing for this alternative.

7.2.4 Alternative B6: Direct Thermal Desorption

Alternative B6: Direct Thermal Desorption (Direct Heating) consists of removing 370,000 BCY of sediments with biota and isolated human health exceedances for treatment by direct thermal desorption. As discussed above, the 51,000 BCY of the more highly contaminated sediments in the inlet are excavated and 310,000 BCY of lake sediments are dredged. Prior to excavation, 2,500 linear ft of temporary cutoff wall is installed to a 5-ft depth to prevent the more highly contaminated sediments agitated during excavation from moving into the lake. After excavation, the disturbed area is backfilled with topsoil and revegetated with wetland species. The dredging of the lake sediments is to be accomplished over a period of 4 years to minimize the impact of dredging on the lake systems. The dredged sediments are pumped to a lined settling basin to reduce the moisture content to approximately 20 percent prior to thermal desorption. Excess water is pumped back to the lakes and could resuspend contaminants in the water. Each year approximately 100,000 BCY of sediments are removed from the lakes and dried in the settling basin.

Dewatered sediments are transported to the thermal desorber located in the northeast corner of Section 2. This unit requires approximately 1 year to build and an additional year for testing before soils are processed. The dredging of the sediments requires 4 years after the construction of the centralized thermal desorption facility, and treatment of the sediments dredged in the final year is complete at the end of year 6 based on the thermal desorption rate. For sediments with a moisture content of 20 percent, the thermal desorber has a processing rate of approximately 1,200 BCY/day and requires a soils residence time of 66 minutes to achieve a soil discharge temperature of 300°C. Approximately 1 percent of the soils feed (3,700 BCY) is collected in the scrubber blowdown and landfilled, and off gases are treated as discussed in Section 4.6.24. Thermal desorption process removes organic carbon and sterilizes the sediments. Backfilling

these treated sediments into the lakes would, therefore, not assist in the restoration of lake habitat, so they are transported to the on-post hazardous waste landfill to be used as daily cover.

Table 7.2-4 details the evaluation of this alternative against the EPA criteria for the DAA. The alternative achieves Biota RAOs in 6 years and reduces migration of contaminants to surface water and groundwater since all contaminated soils are removed and treated to destroy the exceedance COCs. The habitat is restored after remediation, but the dredging operation involves the destruction of 340,000 SY of aquatic habitat and degrades the remaining habitat in the lakes through turbulence and sedimentation. In addition, construction of the settling basin temporarily impacts terrestrial habitat. This impact on biota and habitat may require mitigation to offset these losses. The total estimated present worth cost of this alternative is $76,000,000. Table B3.1-B6 details the costing for this alternative.

7.2.5 Alternative B10: Caps/Covers with Consolidation; In Situ Biological Treatment

Alternative B10: Caps/Covers (Clay/Soil Cap) with Consolidation; In Situ Biological Treatment (Aerobic Biodegradation) addresses exceedances in the Lake Sediments Medium Group in two ways. The human health exceedance volume is excavated, consolidated in Basin A, and covered with a clay/soil cap. The remaining volume of biota exceedance sediments are treated in situ through aerobic biodegradation.

The organic human health exceedance volume of 51,000 BCY contains the highest levels of contamination in the lake sediments. These exceedances, which are near the inlets to the lakes, are grubbed and cleared of aquatic vegetation and then excavated using a backhoe. Prior to excavation, 2,500 linear ft of temporary cutoff walls are installed to prevent the suspended sediments from moving into the lakes. The sediments are then excavated, dewatered, transported to Basin A, consolidated as grading fill over the more highly contaminated soils present in the basin, and contained with a clay/soil cap. The excavated area is backfilled with topsoil and revegetated with wetland species. As discussed in Section 10.2.3., the containment of Basin A requires between 1,200,000 and 1,800,000 BCY of grading fill to achieve design grade for

capping. Consolidation of 51,000 BCY of organic human health exceedances from the Lake Sediments Medium Group removes the highest levels of contamination from the lakes and helps meet the need for grading fill at Basin A.

Following removal of the human health exceedances, the biota exceedance volume of 310,000 BCY is treated via aerobic biodegradation. To date, aerobic biodegradation of the driver OCPs has not been demonstrated at this time. However, recent advances in aerobic biodegradation of similar compounds, such as PCBs, suggest that in the near future aerobic biodegradation techniques for the driver OCPs may be available. The treatment system is designed based on the assumption the techniques will become available.

The system is designed to control the primary factors found to be critical in aerobic biodegradation of similar contaminants, such as PCBs. These include oxygen concentrations, nutrient concentration, and sediment mixing. A combination of indigenous and seeded biota capable of degrading the contaminants may be used. The system is designed to treat only a small portion (5 percent) of lake sediments at one time. In this way, impact to the current thriving ecosystem is reduced. Since the addition of nutrients to the lakes could cause negative impacts on the lakes' ecosystem (ie, eutrophication), the treatment system is designed to isolate the sediments being treated and the water in contact with those sediments from the rest of each lake. It is anticipated that a system of physical barriers with sludge pumps and aerators are used. The barriers are placed into the lake sediments, nutrients are added, and sediment pumping and aeration begins. Concentrations of driver OCPs in sediments are monitored over time for contaminant reductions through degradation.

Table 7.2-5 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative is protective of human health through removal and containment of sediment in Basin A. Once microorganisms and necessary conditions to achieve biodegradation are defined, the alternative also should be able to achieve Biota PRGs. The residual risk is low due to low contaminant concentrations. Severe habitat impact is expected during treatment;

however, treatment areas and volumes at any given time are small and the habitat is improved through removal of contaminants in the long term. Human Health RAOs are achieved in 1 year, but achieving Biota RAOs could take 30 years. Once aerobic biodegradation organisms and conditions have been identified, the alternative will be technically feasible. The alternative is not currently feasible, nor is it at the vendor-implementation level. The total estimated present worth cost of this alternative is $16,000,000. Table B3.1-B10 details the costing for this alternative.

7.3 SELECTION OF PREFERRED ALTERNATIVE

The Lake Sediments Medium Group includes approximately 370,000 BCY of sediments that predominantly present a risk to biota based on aquatic exposure pathways for OCPs, although mercury is also a contaminant of concern. The concentrations of these contaminants are below CRLs or Biota SECs in nearly 98 percent of the samples collected (Table 7.1-2). The average levels of OCPs in the biota exceedance volume are less than 1 ppm (Table 7.1-1), which is substantially lower than the Human Health SEC, but greater than the Biota SEC. Approximately 52,000 BCY of isolated exceedances of the Human Health SEC for chlordane and chromium occur in the sediments. As discussed in Section 7.1, the isolated chromium exceedance is not considered to require remediation. The isolated chlordane exceedances occur near the inlets of the lakes in wetlands areas where concentrations of other OCPs (10 to 50 ppm) are also higher than in the remainder of the lake sediments. These exceedance areas are treated as distinct areas under several of the alternatives for this group in a manner similar to that used for principal threat areas in human health exceedance sites.

The Lake Sediments Medium Group provides high-quality aquatic and wetland habitat with low levels of sediment contamination. The removal of the isolated human health exceedances near the inlets requires the restoration of wetlands, and the removal of all of the lake sediments exceeding Biota SEC entails either dredging or draining the lakes and excavating the sediments. (In order to minimize impacts on surrounding habitat, the removal alternatives are based on dredging the contaminated sediments.) The dredging of contaminated sediments significantly impacts the quality of the benthic habitat and can resuspend contaminated sediments. The

removal and excavation of sediments requires habitat mitigation measures since high-quality habitat would be highly disturbed or eliminated during removal operations. Personnel protective equipment and site controls are capable of protecting site workers and the community during remedial actions.

The Lake Sediments Medium Group presents no human health risks exceeding the SEC (with the exception of isolated chlordane exceedances near the inlets) and relatively low biota risks. In the selection of the preferred alternative for this medium group, the short-term environmental impacts on the high-quality aquatic habitat resulting from dredging or draining the lakes must be balanced against the longer-term low-level risk to aquatic biota of contaminants whose concentrations are gradually reduced by natural attenuation.

Although there is low residual risk for biota, Alternative B1: No Additional Action does not achieve Human Health or Biota RAOs and is eliminated from further consideration as the preferred alternative. The remaining four alternatives achieve Human Health RAOs and meet the EPA threshold criteria (i.e., they are protective of human health and environment and they comply with action-specific and location-specific ARARs). They are distinguished only by the five balancing criteria.

One treatment alternative, Alternative B6: Direct Thermal Desorption exhibits significantly higher costs ($76,000,000) than the remaining alternatives. Alternative B10: Caps/Covers with Consolidation; In Situ Biological Treatment is not currently implementable, and it may not achieve Biota PRGs following treatment depending on how effective the biodegradation system is once appropriate organisms and conditions are identified. In addition, thermal desorption or aerobic biodegradation of the entire biota exceedance area causes significant destruction to habitat, which can only be restored after a number of years. Alternative B3: Landfill requires the excavation of the entire exceedance area and causes the same severe destruction to habitat as the two treatment alternatives.

Alternative B1a: Caps/Covers with Consolidation; No Additional Action, on the other hand, requires excavating only the highest levels of contamination (the human health exceedances) and consolidating them within Basin A prior to the installation of a cap/cover. Consolidation at Basin A minimizes the area of caps/covers at RMA, thereby reducing long-term monitoring and maintenance activities. The excavation of a significantly lower quantity of contaminated material from the lakes minimizes the impact of remedial actions on habitat. Although the risks to biota are low, the levels of residual contamination in the remaining untreated sediments are not anticipated to achieve PRGs through natural attenuation within the 30-year time period used to compare the effectiveness of various alternatives.

The preferred alternative for the Lake Sediments Medium Group is Alternative B1a: Caps/Covers with Consolidation; No Additional Action. Considering the minimal risk to biota from not meeting Biota PRGs in the short term, and the significant impact to habitat from the other alternatives, this alternative is selected as the most environmentally benign and cost-effective alternative.

Table 7.0-1 Characteristics of the Lake Sediments Medium Group[1,2]

Characteristic	Lake Sediments Medium Group
Contaminants of Concern	
Human Health	OCPs, ICP metals
Biota	OCPs, Hg
Exceedance Area (SY)	
Total	380,000
Human Health	40,000
Biota	340,000
Potential Agent	–
Potential UXO	–
Exceedance Volume (BCY)	
Total	370,000
Human Health	52,000
Organic	51,000
Inorganic	1,700
Principal Threat	0
Biota	310,000
Potential Agent	-
Potential UXO	-
Depth of Contamination (ft)	
Human Health	
Biota	0–5
	0–8, mostly 0–3

1 Human health exceedances are isolated detections.
2 All sites were evaluated using biota sediment PRGs.

Table 7.1-1 Summary of Concentrations for the Lake Sediments Medium Group

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC[3] (ppm)
Human Health Exceedance Volume					
Chlordane[2]	4.0–55	23	3.1	260	not applicable
Chromium[2]	150	not applicable	40	10,000	not applicable
Biota Exceedance Volume					
Aldrin	BCRL–25	0.83	56	560	0.316
Dieldrin	BCRL–4.8	0.3	40	400	0.0363
p,p,DDE	BCRL–1.2	0.044	130	1,300	0.0481
p,p,DDT	BCRL–2.1	0.071	26	1,300	0.0514
Mercury	BCRL–17	0.71	470	470,000	0.0351

1 Based on modeled concentrations within exceedance volume.
2 Reported as an isolated exceedance.
3 Concentrations based on Biota Sediment Criteria.

Table 7.1-2 Frequency of Detections for Lake Sediments Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	309	259	83.8%	43	13.9%	7	2.3%	0	0.0%	0	0.0%
Benzene	82	82	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	99	97	98.0%	2	2.0%	--	--	0	0.0%	0	0.0%
Chlordane	309	286	92.6%	20	6.5%	--	--	3	1.0%	0	0.0%
Chlorobenzene	99	99	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroform	99	99	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	309	276	89.3%	32	10.4%	1	0.3%	0	0.0%	0	0.0%
p,p,DDT	309	289	93.5%	19	6.1%	1	0.3%	0	0.0%	0	0.0%
Dibromochloropropane	224	196	87.5%	28	12.5%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	99	99	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	40	40	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	177	177	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	309	260	84.1%	47	15.2%	2	0.6%	0	0.0%	0	0.0%
Endrin	309	293	94.8%	11	3.6%	5	1.6%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	258	253	98.1%	5	1.9%	--	--	0	0.0%	0	0.0%
Isodrin	309	295	95.5%	14	4.5%	--	--	0	0.0%	0	0.0%
Methylene Chloride	99	84	84.8%	15	15.2%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	22	22	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	99	98	99.0%	1	1.0%	--	--	0	0.0%	0	0.0%
Toluene	82	82	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	99	99	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	139	118	84.9%	21	15.1%	0	0.0%	0	0.0%	0	0.0%
Cadmium	187	182	97.3%	5	2.7%	--	--	0	0.0%	0	0.0%
Chromium	187	42	22.5%	144	77.0%	--	--	1	0.5%	0	0.0%
Lead	187	93	49.7%	94	50.3%	--	--	0	0.0%	0	0.0%
Mercury	213	146	68.5%	62	29.1%	5	2.3%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.

Table 7.2-1 Evaluation of Alternative B1: No Additional Action (Provisions of FFA) for the Lake Sediments Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Does achieve Human Health or Biota RAOs as untreated soils remain without implementation of controls. Long-term reduction in toxicity of contaminants due to natural attenuation; surface-water and groundwater impacts not reduced.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs as long-term monitoring and site reviews achieved.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Does not comply with location-specific ARARs as Lake Sediments Medium Group located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Chlordane and chromium above Human Health SEC and OCPs and mercury above Biota SEC remain in sediments and continue to impact human health and biota.
b) Adequacy and reliability of controls	b) No controls implemented. Site reviews, groundwater and surface-water monitoring required.
c) Habitat impacts	c) Habitat quality not improved. Existing high-quality habitat not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction in contaminant volume or mobility except by natural attenuation; 370,000 BCY of untreated sediments remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or vapor emissions.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Existing high-quality habitat not impacted by remedial alternative; migration of contaminants to groundwater and surface water not reduced.
d) Time until RAOs are achieved	d) >30 years. Natural attenuation only process for contaminant reduction.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Monitoring services readily available.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $2,200,000
d) Total	d) $2,200,000

Table 7.2-2 Evaluation of Alternative B1a: Caps/Covers (Clay/Soil Cap) with Consolidation; No Additional Action (Provisions of FFA) for the Lake Sediments Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health but does not achieve Biota RAOs in short term as low levels of contamination left in place; achieves Human Health RAOs as sediments above Human Health SEC excavated and consolidated in Basin A for containment with clay/soil caps; surface-water and groundwater impacts reduced but impacts may contiue as only highest levels of contamination removed.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document Appendix A, Tables A-1 and A-5)	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin A not located in wetlands or 100-year floodplain; wetlands restored after excavation.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 51,000 BCY of untreated sediments consolidated and contained in Basin A with clay/soil cap; OCPs and mercury above Biota SEC (average concentrations from 0.04 ppm for p,p,DDE to 0.83 ppm for aldrin) remain in sediments and continue to impact biota.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for Basin A: high confidence in engineering controls of clay/soil cap in Basin A.
c) Habitat impacts	c) Habitat quality restored. Revegetation of high-quality habitat at inlets restored after limited excavation; remaining high-quality habitat not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Exposure pathways interrupted and mobility of contaminants reduced through consolidation of 51,000 BCY of sediments in Basin A and installation of clay/soil cap in Basin A; no reduction in contaminant volume or mobility except by natural attenuation for balance of site; 310,000 BCY of untreated sediments remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if Basin A cap degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation and transportation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts and vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Habitat restored after disturbance of high-quality habitat at inlet due to limited excavation; mitigation of wetlands may be required; migration of contaminants to groundwater and surface water reduced but ongoing as only highest levels of contamination removed.
d) Time until RAOs are achieved	d) >30 years. Natural attenuation of untreated sediments ongoing but takes longer than 30 years to achieve PRGs; consolidation of 51,000 BCY of sediments in Basin A feasible within 1 year.

Table 7.2-2 Evaluation of Alternative B1a: Caps/Covers (Clay/Soil Cap) with Consolidation; No Additional Action (Provisions of FFA) for the Lake Sediments Medium Group

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative implemented within required time frame and reliably maintained thereafter; additional remedial actions require removal of cap\cover in Basin A.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of cap/cover design and construction regulations; wetlands at inlets restored after excavation.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment readily available for consolidation and clay/soil cap construction; clay/soil caps well documented at full scale.
7. Present worth costs	
a) Capital	a) 0
b) Operating	b) $3,600,000
c) Long-term	c) $2,200,000
d) Total	d) $5,700,000

Table 7.2-3 Evaluation of Alternative B3: Landfill (On-Post Landfill) for the Lake Sediments Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; contaminated soils contained in on-post landfill, preventing biota exposure; groundwater and surface-water impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document Appendix A, Table A-1 and A-8)	a) Complies with action-specific ARARs including state regulations on landfill siting, design, and operation; endangered species not impacted, although habitat in southern tier slightly reduced during dredging.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as landfill not located in wetlands or 100-year floodplain; wetlands restored after dredging.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 370,000 BCY of untreated sediments contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls of landfill.
c) Habitat impacts	c) Habitat quality restored at site. High-quality aquatic and wetland habitat restored at site following dredging, but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Exposure pathways interrupted and mobility of contaminants reduced through containment of 370,000 BCY in on-post landfill.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during dredging and transportation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts and vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Moderate environmental impacts. Moderate impact to biota as high-quality habitat destroyed during dredging; mitigation of habitat required; migration of contaminants to groundwater and surface water reduced.
d) Time until RAOs are achieved	d) 6 years. Dredging of 370,000 BCY feasible within 5 years after 1 year for construction of on-post landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cells monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of landfill siting, design, and operating regulations; wetlands restored after dredging.
c) Availability of services and materials	c) Readily implemented. Equipment, specialists, and materials (including clay) readily available for construction of landfill; landfills well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $ 8,600,000
b) Operating	b) $14,000,000
c) Long-term	c) $ 1,200,000
d) Total	d) $24,000,000

Table 7.2-4 Evaluation of Alternative B6: Direct Thermal Desorption (Direct Heating) for the Lake Sediments Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to OCP detection level and inorganics reduced below Biota SEC; treated soils used as cover material for on-post landfill; blowdown solids placed in on-post landfill; groundwater and surface water impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs Technology Description Document Appendix A, Tables A-1, A-8, and A-10)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation achieved; endangered species not impacted, although habitat slightly reduced in southern tier during excavation.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as thermal desorption facility and landfill not located in wetlands or 100-year floodplain; wetlands restored after dredging.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 370,000 BCY thermally desorbed and landfilled; approximately 1% of solids feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Backfill monitoring not required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality restored. High-quality wetland and aquatic habitat restored after dredging.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 370,000 BCY thermally desorbed to degrade OCPs and remove mercury.
b) Degree and quantity of TMV reduction	b) OCPs reduced to below detection levels (>99.99% destruction removal efficiency). TMV of OCPs eliminated; mercury removed below Biota SEC; ICP metals reduced below Human Health SEC following solids blending as a pre-treatment and limited volatilization during thermal desorption (20% to 30%); scrubber blowdown solids from off-gas treatment equipment with mercury, ICP metals, and salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible.
d) Type and quantity of treatment residuals	d) 3,700 BCY of blowdown solids with mercury, ICP metals, and salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during dredging, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts and vapor emissions not anticipated from dredging; vapor emissions associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Moderate environmental impacts. Moderate impact to biota as high-quality habitat destroyed during dredging; mitigation of habitat required.
d) Time until RAOs are achieved	d) 6 years. Excavation and treatment of 370,000 BCY feasible within 4 years after 2 years for construction of thermal desorption facility and landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cell monitored.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of thermal treatment unit and landfill siting, design, and operating regulations; wetlands restored after dredging
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers; equipment, specialists, and materials readily available for construction of landfill; thermal desorbers and landfills well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $18,000,000
b) Operating	b) $57,000,000
c) Long-term	c) $ 1,100,000
d) Total	d) $76,000,000

Table 7.2-5 Evaluation of Alternative B10: Caps/Covers (Clay/Soil Cap) with Consolidation; In Situ Biological Treatment (Aerobic Biodegradation) for the Lake Sediments Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health, and achieves Human Health RAOs as sediments above Human Health SEC excavated and consolidated in Basin A for containment; Biota PRGs may be achieved if necessary biodegradation techniques become available; surface-water and groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document Appendix A, Tables A-1, A-5, and A-20)	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin A not located in wetlands or 100-year floodplain; wetlands restored after excavation.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 51,000 BCY of untreated sediments consolidated and contained in Basin A with clay/soil cap; 310,000 BCY treated in place but ability to meet Biota PRGs questionable.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for Basin A; high confidence in engineering controls of clay/soil cap in Basin A.
c) Habitat impacts	c) Habitat quality restored. High-quality habitat at inlets restored after limited excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) Exposure pathways interrupted and mobility of contaminants reduced through consolidation of 51,000 BCY in Basin A and installation of clay/soil cap in Basin A; 310,000 BCY of sediments treated by biodegradation in place but ability to meet Biota PRGs questionable.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if Basin A cap degrades or leaks; TMV reduction by biodegradation irreversible in treated sediments.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation, transportation, and in situ treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts and vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Severe environmental impacts. Habitat restored after limited excavation; in situ biodegradation results in destruction of habitat as conditions of lakes changed; mitigation of wetlands may be required; migration of contaminants to surface water and groundwater ongoing.
d) Time until RAOs are achieved	d) 30 years. Consolidation of 51,000 BCY feasible in 1 year; biodegradation of 310,000 BCY last 30 years.
6. Implementability	
a) Technical feasibility	a) Potentially technically feasible. Biodegradation feasible once aerobic organisms and conditions identified; consolidation implemented within required time frame and reliably maintained thereafter; additional remedial actions require removal of Basin A cap/cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of cap/cover design and construction and biodegradation operation.
c) Availability of services and materials	c) Limited availability. Equipment and materials are not available for full-scale biodegradation of lake sediments; materials, specialists, and equipment readily available for clay/soil cap construction; clay/soil caps well documented at full scale.

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $16,000,000
c) Long-term	c) $0
d) Total	d) $16,000,000

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DATE 3/2/93
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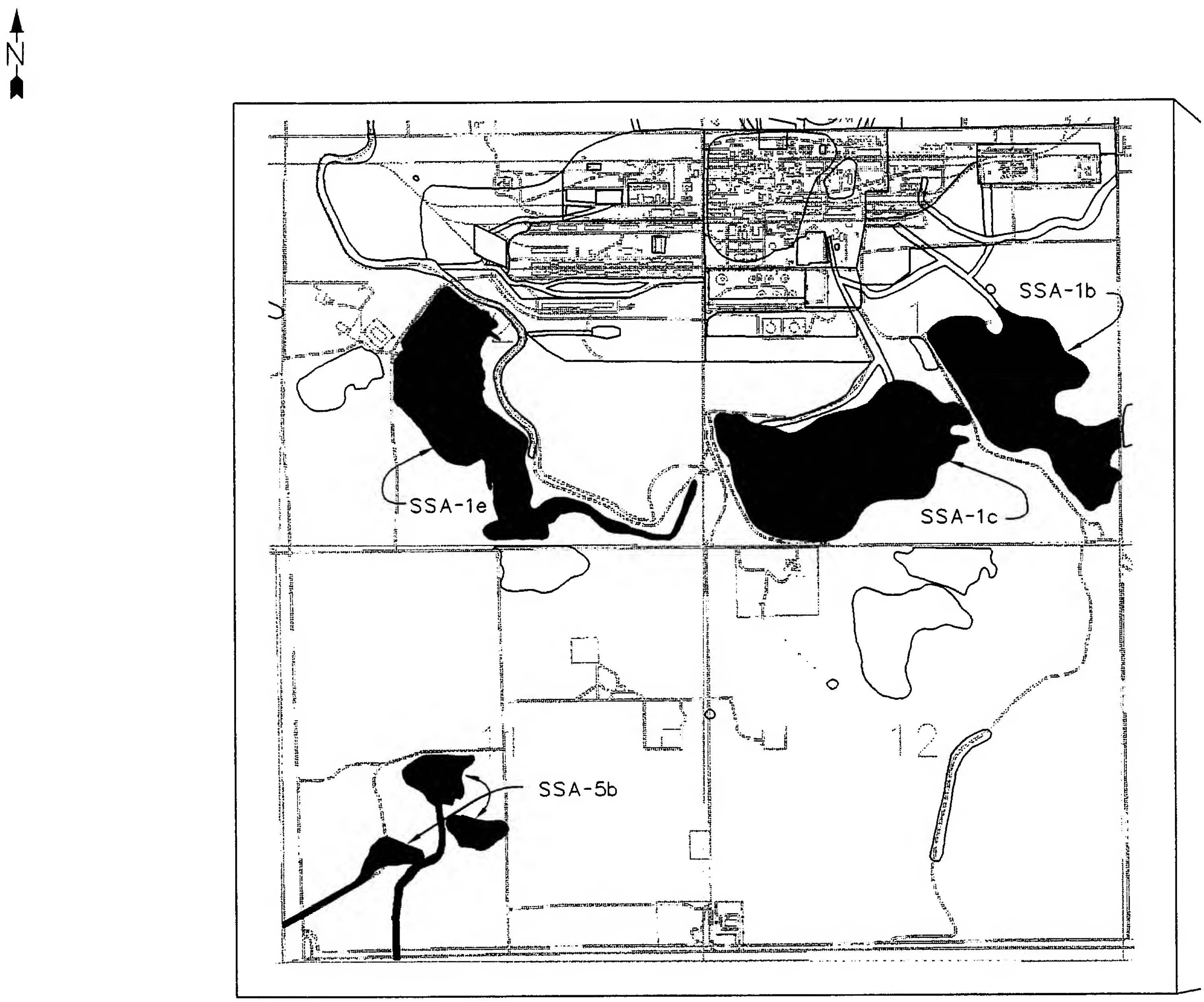


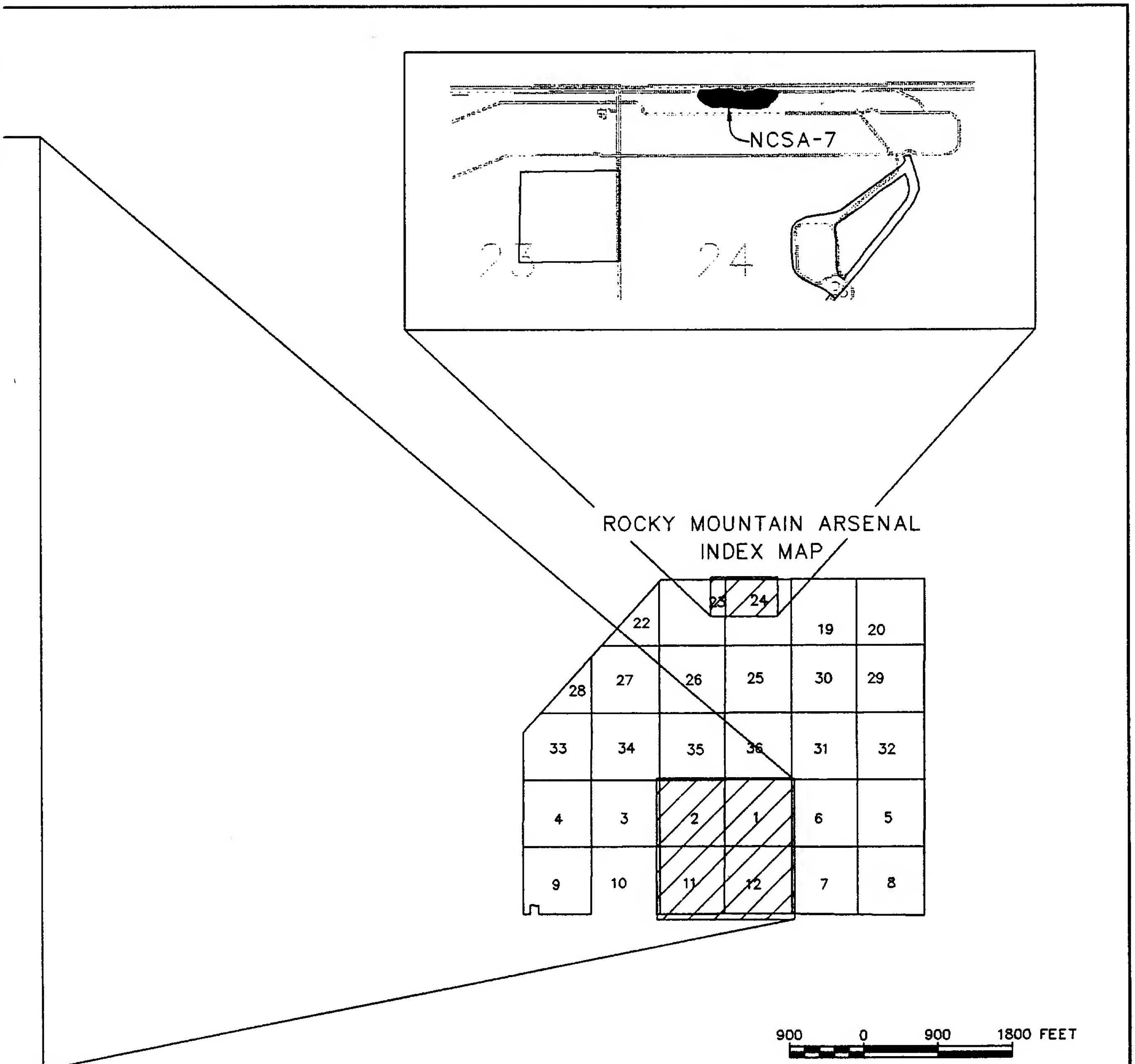
LEGEND

Lake Sediments Medium Group
SITES: SSA-1b, Upper Derby
SSA-1c, Lower Derby
SSA-1e, Lake Ladora
SSA-5b, Havana/Peoria Street Ponds
NCSA-7, North Bog

Site Boundary

Buildings and Roads

2 Section Number



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 7.0-1

Site Locations
Lake Sediments Medium Group

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated

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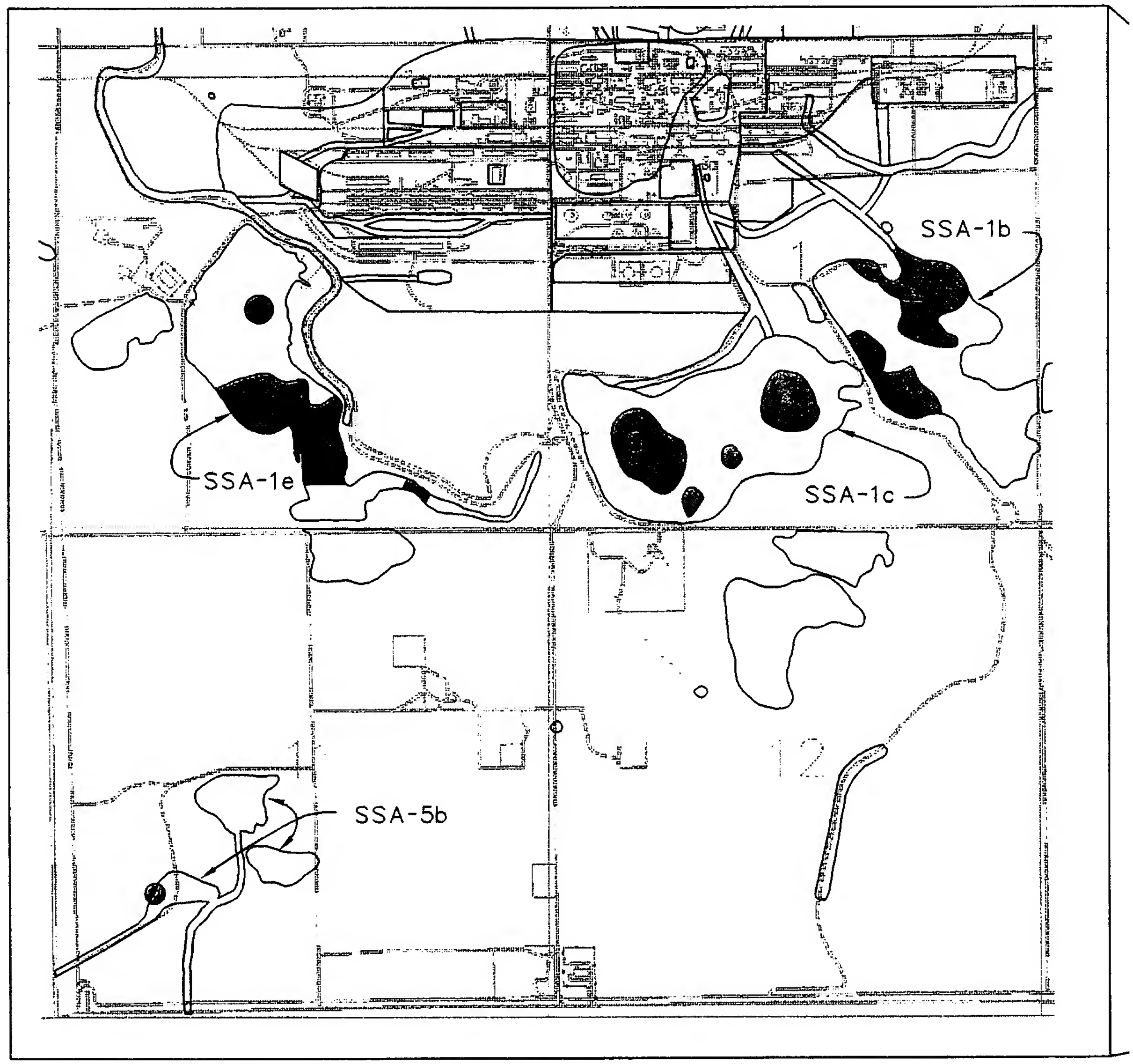


LEGEND

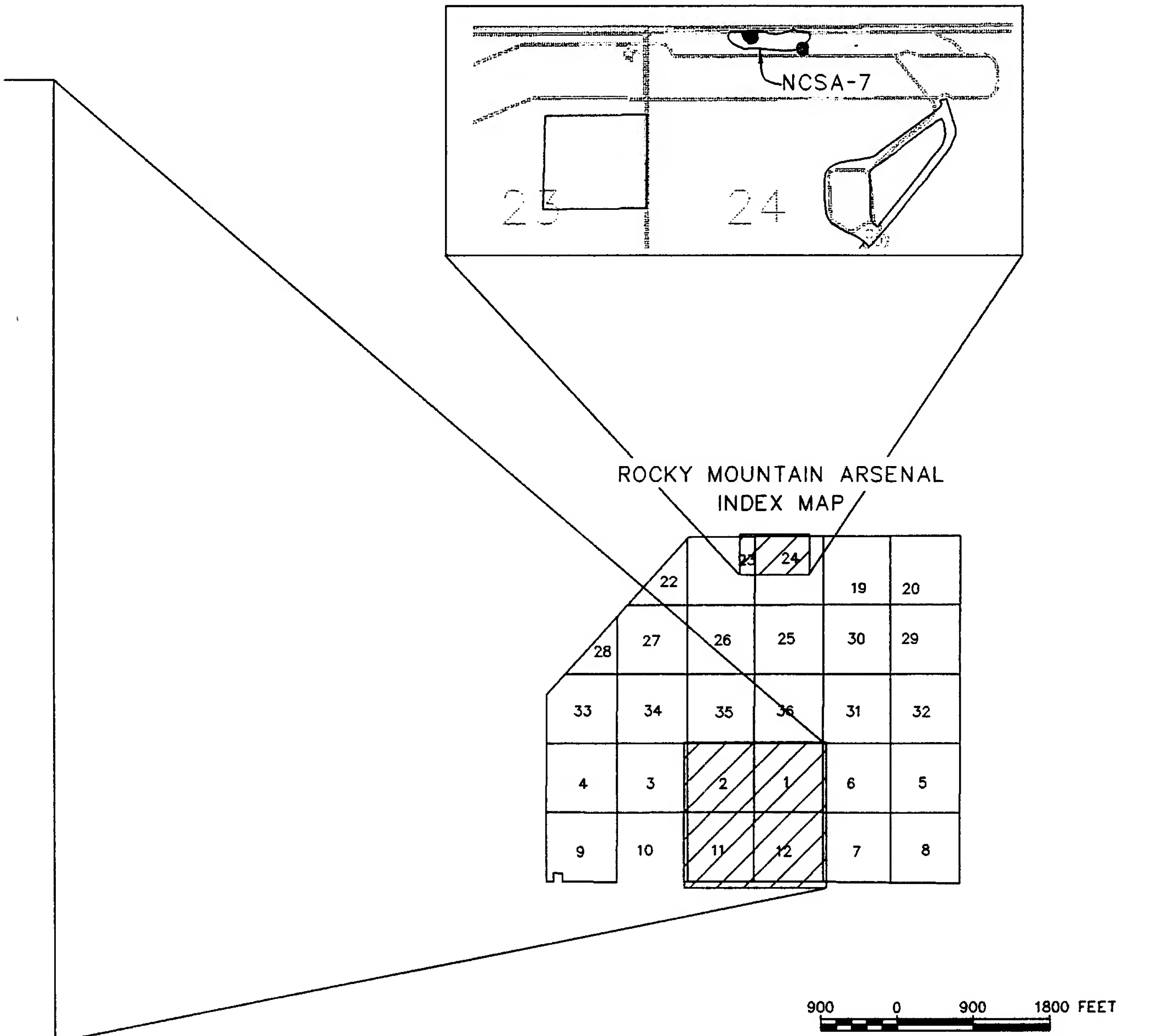
Biota Exceedance Area

Human Health Exceedance Area

Site Boundary

Buildings and Roads

Section Number



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 7.1-1

Exceedance Areas
Lake Sediments Medium Group

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated

8.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE SURFICIAL SOILS MEDIUM GROUP

The Surficial Soils Medium Group is composed of one SAR site and several areas outside of the boundaries of the SAR sites that are located primarily in the center of RMA (Figure 8.0-1). Areas outside of the SAR sites were defined based on a surficial soils survey conducted to assess the potential for windblown contamination as discussed in the RISR (EBASCO 1992a/RIC 92017R01). These sites were grouped based on the potential risks they present to biotic receptors. Sampling results indicate that soils in this medium group generally do not threaten human health.

The COCs present in this medium group are OCPs, which generally exceed only the Biota SEC. A small area of human health exceedance for chlordane also exists in the Eastern Study Area. Areas within this medium group are not potential sources of groundwater or surface-water contamination. Table 8.0-1 presents the characteristics of this medium group, including exceedance volumes and COCs, and Appendix A presents the calculations of volumes.

In the DSA, alternatives were developed and screened based on the general characteristics of the medium group. In the DAA, individual subgroups were not developed for the sites, so the retained alternatives apply to the Surficial Soils Medium Group as a whole. The characteristics of the sites in this medium group—including contaminant types and containment concentrations, site configuration, and depth of contamination—were evaluated to determine whether any changes to the retained alternatives for this medium group were appropriate. No modifications were made to the four alternatives retained from the DSA.

The following sections present the characteristics of the medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection of a preferred alternative based on a comparative analysis of the alternatives. The preferred alternative is as follows:

- Alternative B9—In situ treatment of biota exceedances in surficial soil by landfarm/agricultural practice. No action undertaken for isolated human health exceedance due to the high habitat value of the area as a bald eagle roost.

8.1 MEDIUM GROUP CHARACTERISTICS

The Surficial Soils Medium Group is composed of site NCSA-1g and areas of surficial-soil contamination outside the boundaries of the SAR sites (Figure 8.1-1). These sites contain soils that were contaminated by windblown dust. Soil sampling at locations within this medium group was generally limited to the upper 2 inches of soil.

Table 8.1-1 provides a summary of contaminants, concentrations, and corresponding exceedance values for the medium group. Table 8.1-2 summarizes the frequency of detections for soil samples taken in this medium group. The table shows that chlordane was detected at concentrations exceeding the Human Health SEC in 2 samples and exceedance volume concentrations range from 3.1 ppm to 4.9 ppm. These low-level exceedances are located in a small area of soil within the Bald Eagle Management Area, a high-quality, irreplaceable habitat. Remedial alternatives, therefore, were not developed for the human health exceedance in this area. OCPs were detected above the Biota SEC in less than 2 percent of the samples at low concentrations (a maximum of 0.07 ppm for endrin and 2.2 ppm for dieldrin). The biota exceedance area amounts to approximately 5,500,000 SY of RMA, which represents 810,000 BCY of contaminated soils (not including the 9,600 BCY of human health exceedance volume) based on an inferred 6-inch depth of contamination. Table 8.0-1 summarizes the volumes for the medium group.

This medium group does not impact groundwater quality, and the alternatives evaluated do not require the demolition or removal of structures. The exceedance area does incorporate several structures, but remediation of the soils beneath the structures is not required based on historical usage and depth of contamination.

The Surficial Soils Medium Group exhibits moderate to very high habitat values and wildlife potential. Some of the area lies within prairie dog colonies, and other areas are located within the Bald Eagle Management Area. Therefore, the evaluation of alternatives for this medium group must consider the impacts of alternatives on the habitat within these sites. Areas disturbed during remediation are to be revegetated with native grasses in accordance with a refuge management plan, which improves the habitat value for portions of the medium group.

8.2 EVALUATION OF ALTERNATIVES

The four alternatives for the Surfical Soils Medium Group vary in approach from no action to treatment. The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA.

8.2.1 Alternative B1: No Additional Action

Alternative B1: No Additional Action (Provisions of FFA) applies to 5,500,000 SY contained in the Surficial Soils Medium Group. This area encompasses approximately 810,000 BCY of soils with biota exceedances. Under this alternative, no action is taken to limit biota or human exposure to COCs, and contaminated soils are left in place without controls being implemented. Long-term monitoring of untreated soils is conducted (an average of 11 samples per year), and 5-year reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Table 8.2-1 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative does not achieve Human Health and Biota RAOs in the short term as untreated soils remain in place. Natural attenuation of contamination is ongoing, but the estimated time frame to achieve PRGs is more than 30 years. The residual risk is low due to the low levels of contamination in the soil. The moderate- to high-value habitat found in these areas is not disturbed. The total present worth cost of this alternative is $800,000. Table B3.2-B1 details the costing for alternative.

8.2.2 Alternative B3: Landfill

Alternative B3: Landfill (On-Post Landfill) involves excavating 810,000 BCY of biota exceedance volume and disposing it in an on-post landfill. The landfill facility has a capacity for multiple cells and requires 1 year for construction of the first cell and associated support facilities. Topsoil is placed over the excavated area of 5,500,000 SY and the area is revegetated, thus restoring the habitat at the site. Long-term activities required for the containment of untreated soils in the landfill include leachate collection and treatment, monitoring of potential leachate migration, revegetation and maintenance of the landfill cover, and fencing to exclude biota.

Table 8.2-2 details the evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs since the contaminated soils are excavated and transferred to a containment cell. The residual risk achieves PRGs at the site. This alternative requires approximately 2 years, including a 1-year construction time for the landfill cell. The alternative has a significant impact on biota and habitat due to widespread excavation. Habitat is restored after the alternative is completed. The estimated present worth cost of this alternative is $75,000,000. Table B3.2-B9 details the costing for this alternative.

8.2.3 Alternative B9: In Situ Biological Treatment

Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) applies to 5,500,000 SY of biota exceedance soils in the Surficial Soils Medium Group. This alternative consists of mimicking agricultural practices through tilling, seeding, mulching, and fertilizing. As has been shown in many studies of agricultural soils, the concentrations of OCPs such as dieldrin and aldrin decrease with time when subjected to agricultural practices. In addition to decreasing contaminant concentration, this alternative minimizes the potential for surface-receptor contact with the existing contaminated surficial soils. The ease of revegetation in treated areas minimizes impacts on habitat.

The tilling and mixing of the soils is accomplished with traditional farm equipment or with a soil mixing device like those commonly used for damaged roadbed reclamation. The depth of remediation is from the surface to 12 to 18 inches in depth. Species chosen for reseeding are based on an evaluation of desired habitat. Since treatment takes place in situ and the mechanisms of contaminant degradation are not well understood, long-term monitoring until contaminant concentrations are below remediation goals is required. Monitoring consists of an average of 11 soil samples per year. Five-year site reviews are performed to review the effectiveness of the alternative.

Table 8.2-3 details the evaluation of this alternative against the EPA criteria for the DAA. The alternative is expected to be protective of human health and the environment as RAOs are achieved through treatment. The residual risk is low, but Biota PRGs may not be met. Following treatment, long-term controls are not required. A moderate impact to biota occurs because a large area of soils is disturbed; however, performing the treatment in a checkerboard pattern minimizes the overall impact on the ecosystem. Additionally, the habitat is improved through revegetation with selected species that match the desired ecosystem. The time frame for achieving RAOs cannot be conclusively determined since the mechanisms of contaminant degradation are not well understood, but a 4-year period was assumed for costing purposes. The total present worth cost of this alternative is $2,800,000. Table B3.2-B9 details the costing for this alternative.

8.2.4 Alternative B11: In Situ Thermal Treatment

Alternative B11: In Situ Thermal Treatment (Surface Soil Heating) treats 5,500,000 SY of biota exceedance soils that contain OCPs. Surface soil heating raises the temperature of the soils to more than 250°C, mobilizing the organic contaminants located in the near-surface soils. The mobilized contaminants are collected and treated in the off-gas treatment system (Section 4.5.9). Twelve surface soil modules or units are to be used for the Surficial Soils Medium Group. A surface soil unit treats a block of soil with dimensions of 50 ft by 50 ft and has a treatment rate

of approximately 3.5 acres or 17,000 SY per year. The liquid sidestream from in situ heating, which contains predominantly salts, is transported to the centralized thermal desorption facility for treatment in the scrubber effluent treatment system for that facility. A 6-inch layer of topsoil is placed over the treated biota area of 5,500,000 SY to provide a medium for revegetation with native grasses.

Table 8.2-4 details the evaluation of this alternative against the EPA criteria for the DAA. Surface soil heating can theoretically achieve RAOs with low residual risk. The treatment reduces OCP levels to near Biota PRGs, but may not achieve them. There is a significant short-term environmental impact due to the disturbance of habitat through treatment over a widespread area and the difficulties associated with placing topsoil over 5,500,000 SY. The implementability of in situ surface soil heating is questionable since there is no commercial source for the equipment and the technique is as yet unproven at full scale. The treatment of 5,500,000 SY of contaminated soils is feasible within 27 years. The estimated present worth cost of this alternative is $190,000,000. Table B3.2-B11 details the costing for this alternative.

8.3 SELECTION OF PREFERRED ALTERNATIVE

The Surficial Soils Medium Group consists of 820,000 BCY of exceedance soils in the upper 6 inches of the soils. The exceedances, attributed to windblown dust, and are primarily OCP exceedances that represent a risk to biota. The OCP concentrations exceed the Biota SEC in less than 2 percent of the samples collected (Table 8.1-2). The risk to biota is low as the average OCP concentrations within the biota exceedance volume are below or only slightly above the Biota SEC (Table 8.1-1). Chlordane was detected above the Human Health SEC in 0.1 percent of the samples for this subgroup (Table 8.1-2). The 9,600 BCY of resulting human health exceedance volume presents a low risk to human health since the average concentration of this volume only marginally exceeds the Human Health SEC (Table 8.1-1). As discussed in Section 8.1, remedial alternatives were not evaluated for this area based on the isolated nature of the exceedance, low risk, and high-quality habitat.

This subgroup provides moderate to very high quality habitat and includes areas within prairie dog colonies and the Bald Eagle Management Area. The selection of the preferred alternative must consider the impacts of remediation on habitat. Areas disturbed during remediation are to be revegetated to restore and improve habitat value.

In summary, the Surficial Soils Medium Group presents a low risk to biota and a very limited area of low risk for human health. The selection of the preferred alternative must address habitat impacts as an important consideration.

Alternative B1: No Additional Action does not achieve Biota RAOs and is eliminated from further consideration in selecting the preferred alternative. The remaining three alternatives achieve RAOs and meet the two DAA threshold criteria: protection of human health and the environment and compliance with action-specific and location-specific ARARs for the DAA. Since the three alternatives all satisfy both of the threshold criteria, they are distinguished by how they satisfy the five balancing criteria (Tables 8.2-1 through 8.2-4).

Alternative B3: Landfill does not treat the contaminants prior to containment and requires the excavation of 810,000 BCY of soils over a widespread area (5,500,000 SY). Alternative B11: In Situ Thermal Treatment achieves RAOs through treatment, but this alternative impacts the quality of the soils, causing difficulties in revegetation, and has a significantly higher cost ($190,000,000) than the other two protective alternatives. Alternative B9: In Situ Biological Treatment has the lowest cost ($2,800,000) of the protective alternatives and results in reduced impacts on habitat as the topsoil is not removed or thermally modified.

The preferred alternative for the Surficial Soils Medium Group is Alternative B9: In Situ Biological Treatment. This alternative does not negatively impact the physical state of the soils during remediation as does Alternative B11: In Situ Thermal Treatment, and the soils are readily revegetated. As a result, the impact on habitat, which is a significant consideration for this medium group, is less than for the other alternatives. This alternative is cost effective since the

large exceedance area is treated in place and the area can readily be revegetated at a lower cost than the other protective alternatives.

Table 8.0-1 Characteristics of the Surficial Soils Medium Group

Characteristic	Surficial Soils Medium Group
Contaminants of Concern	
Human Health[1]	chlordane
Biota	OCPs
Exceedance Area (SY)	
Total	5,500,000
Human Health[1]	38,000
Biota	5,500,000
Potential Agent	not applicable
Potential UXO	not applicable
Exceedance Volume (BCY)	
Total	820,000
Human Health[1]	9,600
Organic	9,600
Inorganic	0
Principal Threat	0
Biota	810,000
Potential Agent	not applicable
Potential UXO	not applicable
Depth of Contamination (ft)	0–0.5
Human Health	0–0.5
Biota	

1 No action is undertaken for the isolated human health exceedance due to location within Bald .... Management Area.

Table 8.1-1 Summary of Concentrations for the Surficial Soils Medium Group

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC (ppm)
<u>Human Health Exceedance Volume</u>					
Chlordane	3.1–4.9	3.9	3.1	260	not applicable
<u>Biota Exceedance Volume</u>					
Aldrin	0.006–0.54	0.035	56	560	0.68
Dieldrin	0.047–2.2	0.26	40	400	0.83
Endrin	0.009–0.07	0.032	15	15,000	0.029

1 Based on modeled concentrations within exceedance volume.

Table 8.1-2 Frequency of Detections for Surficial Soils Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	2062	1900	92.1%	160	7.8%	2	0.1%	0	0.0%	0	0.0%
Benzene	360	359	99.7%	1	0.3%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	352	352	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	2026	1990	98.2%	34	1.7%	--	--	2	0.1%	0	0.0%
Chloroacetic Acid	117	116	99.1%	0	0.0%	--	--	1	0.9%	0	0.0%
Chlorobenzene	354	353	99.7%	1	0.3%	--	--	0	0.0%	0	0.0%
Chloroform	352	352	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	2034	1994	98.0%	37	1.8%	3	0.1%	0	0.0%	0	0.0%
p,p,DDT	2034	1896	93.2%	138	6.8%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	1869	1868	99.9%	1	0.1%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	352	352	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	105	105	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	1861	1861	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	2066	1783	86.3%	275	13.3%	8	0.4%	0	0.0%	0	0.0%
Endrin	2062	1936	93.9%	96	4.7%	30	1.5%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	2017	2010	99.7%	7	0.3%	--	--	0	0.0%	0	0.0%
Isodrin	2034	1992	97.9%	42	2.1%	--	--	0	0.0%	0	0.0%
Methylene Chloride	335	328	97.9%	7	2.1%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	67	67	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	352	352	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Toluene	361	360	99.7%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	352	352	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	1839	1602	87.1%	236	12.8%	0	0.0%	1	0.1%	0	0.0%
Cadmium	1749	1691	96.7%	58	3.3%	--	--	0	0.0%	0	0.0%
Chromium	1716	399	23.3%	1316	76.7%	--	--	1	0.1%	0	0.0%
Lead	1727	1183	68.5%	544	31.5%	--	--	0	0.0%	0	0.0%
Mercury	1852	1783	96.3%	66	3.6%	3	0.2%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.

Table 8.2-1 Evaluation of Alternative B1: No Additional Action (Provisions of FFA) for the Surficial Soils Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Does not achieve Biota RAOs as untreated soils remain and controls are not implemented. Long-term reduction in toxicity of contaminants through natural attenuation; human health exceedance not addressed due to low levels of chlordane (5 ppm) located in a high-quality, irreplaceable habitat; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Compliance with action-specific ARARs as long-term monitoring and site reviews achieved.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Surficial Soils Medium Group not located in wetlands or 100-year flood plain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Low levels of OCPs (average concentrations up to 0.26 ppm) above Biota SEC remain in surface soils and may continue to impact biota.
b) Adequacy and reliability of controls	b) No controls implemented. Site reviews required.
c) Habitat impacts	c) Habitat quality not improved. Existing moderate- to high-quality habitat not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction in contaminant volume or mobility except by natural attenuation; 810,000 BCY of untreated soils remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or emissions.
c) Environmental impacts of remedial actions	c) No impacts to environment. Existing moderate- to high-quality habitat not impacted by remedial alternative.
d) Time until RAOs are achieved	d) >30 years. Natural attenuation only process for contaminant reduction.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Monitoring services readily available.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $800,000
d) Total cost	d) $800,000

Table 8.2-2 Evaluation of Alternative B3: Landfill (On-Post Landfill) for the Surficial Soils Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; contaminated soils contained in on-post landfill preventing biota exposure; human health exceedance not addressed due to low levels of chlordane located in a high-quality, irreplaceable habitat; no unacceptable cross-media impacts but significant short-term impacts on habitat.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-8)	a) Complies with action-specific ARARs including state regulations on landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Surficial Soils Medium Group and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 810,000 BCY of untreated soil contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls of landfill.
c) Habitat impacts	c) Habitat quality restored at site. Revegetation of disturbed areas restores moderate- to high-quality habitat at site, but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Exposure pathways interrupted and mobility of contaminants reduced through containment of 810,000 BCY in on-post landfill.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation and transportation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Significant environmental impacts. Significant impact to biota due to widespread excavation and destruction of moderate- to high-quality habitat.
d) Time until RAOs are achieved	d) 2 years. Excavation of 810,000 BCY feasible within 1 year after 1 year for construction of landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cells monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily implemented. Equipment, specialists, and materials (including clay) readily available for construction of landfill; landfills well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $16,000,000
b) Operating	b) $56,000,000
b) Long-term	c) $3,100,000
c) Total cost	d) $75,000,000

Table 8.2-3 Evaluation of Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Surficial Soils Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment but Biota PRGs may not be attained; no unacceptable short-term or cross-media impacts; human health exceedance not addressed due to low levels of chlordane located in a high-quality, irreplaceable habitat.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Table A-1)	a) Complies with action-specific ARARs including state regulations on air emissions sources; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Surficial Soils Medium Group not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk may not achieve PRGs. 5,500,000 SY landfarmed to reduce TMV.
b) Adequacy and reliability of controls	b) No controls implemented. Site reviews and long-term monitoring required.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing moderate-to high-quality habitat.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) Landfarm/agricultural practice reduces TMV of 5,500,000 SY of surficial soils.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) TMV reduction by landfarm/agricultural practice irreversible.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with treatment.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during in situ treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Moderate environmental impacts. Moderate impact to biota as moderate- to high-quality habitat disturbed over large area but revegetated after treatment; mitigation may be required.
d) Time until RAOs are achieved	d) 4 years. Treatment of 5,500,000 SY feasible in 4 years.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative implemented within required time frame and reliably maintained thereafter; additional remedial action easily undertaken.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Readily implemented. Equipment, specialists, and materials readily available for landfarm/agricultural practice.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $2,200,000
c) Long-term	c) $670,000
d) Total	d) $2,800,000

Table 8.2-4 Evaluation of Alternative B11: In Situ Thermal Treatment (Surface Soil Heating) for the Surficial Soils Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment, but concentrations not reduced to achieve PRGs for point of departure; no unacceptable cross-media impacts, but significant short-term impacts on habitat; human health exceedance not addressed due to low levels of chlordane located in a high-quality, irreplaceable habitat.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Table A-13)	a) Complies with action-specific ARAR's including state regulations on air emissions sources; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Surficial Soil Medium Group not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk within acceptable range. 5,500,000 SY thermally treated in place but Biota PRGs not achieved.
b) Adequacy and reliability of controls	b) Controls not required. Monitoring of treated soil not required.
c) Habitat impacts	c) Habitat quality restored. Revegetation of disturbed area restores moderate- to high-quality habitat, but some biota risk remains as Biota PRGs not achieved.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 5,500,000 SY thermally treated to degrade OCPs.
b) Degree and quantity of TMV reduction	b) TMV of OCPs reduced during surface soil heating (>99% destruction removal efficiency), but concentrations after treatment unable to achieve Biota PRGs.
c) Irreversibility of TMV reduction	c) TMV reduction by surface soil heating irreversible.
d) Type and quantity of treatment residuals	d) Liquid sidestream from air emission control equipment treated at centralized thermal desorption facility with scrubber effluent.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during in situ thermal treatment.
b) Protection of community during remedial action	b) Protective of community. No fugitive dust emissions; vapor emissions associated with surface soil heating controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Significant environmental impact. Significant impact on biota as widespread disturbance of moderate- to high-quality habitat and revegetation difficult after treatment requiring the installation of topsoil over 5,500,000 SY.
d) Time until RAOs are achieved	d) 27 years. Surface soil heating of 5,500,000 SY feasible within 27 years.
6. Implementability	
a) Technical feasibility	a) Potentially technically feasible. Pilot-scale testing of surface soil heating on soils with similar contaminants was successful but unproven at full scale; additional remedial actions easily undertaken for treated soils that do not achieve PRGs.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment equipment siting, design, and operating regulations.
c) Availability of services and material	c) Limited availability. Equipment custom designed for each application and not available; specialists only available through process licenser; no full-scale demonstration of surface soils heating equipment.
7. Present worth costs	
a) Capital	a) \$19,000,000
b) Operating	b) \$170,000,000
c) Long-term	c) \$0
d) Total	d) \$190,000,000

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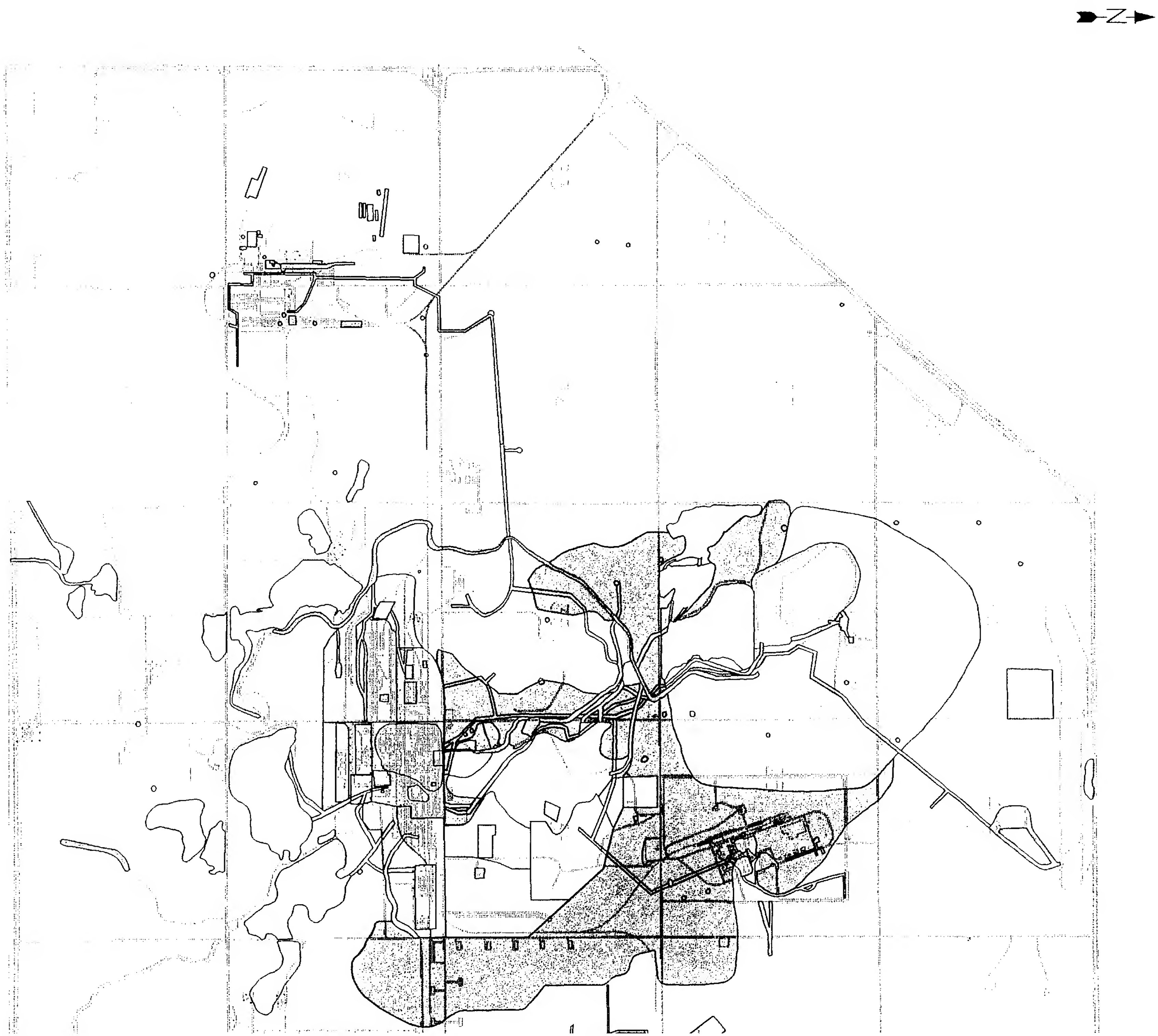
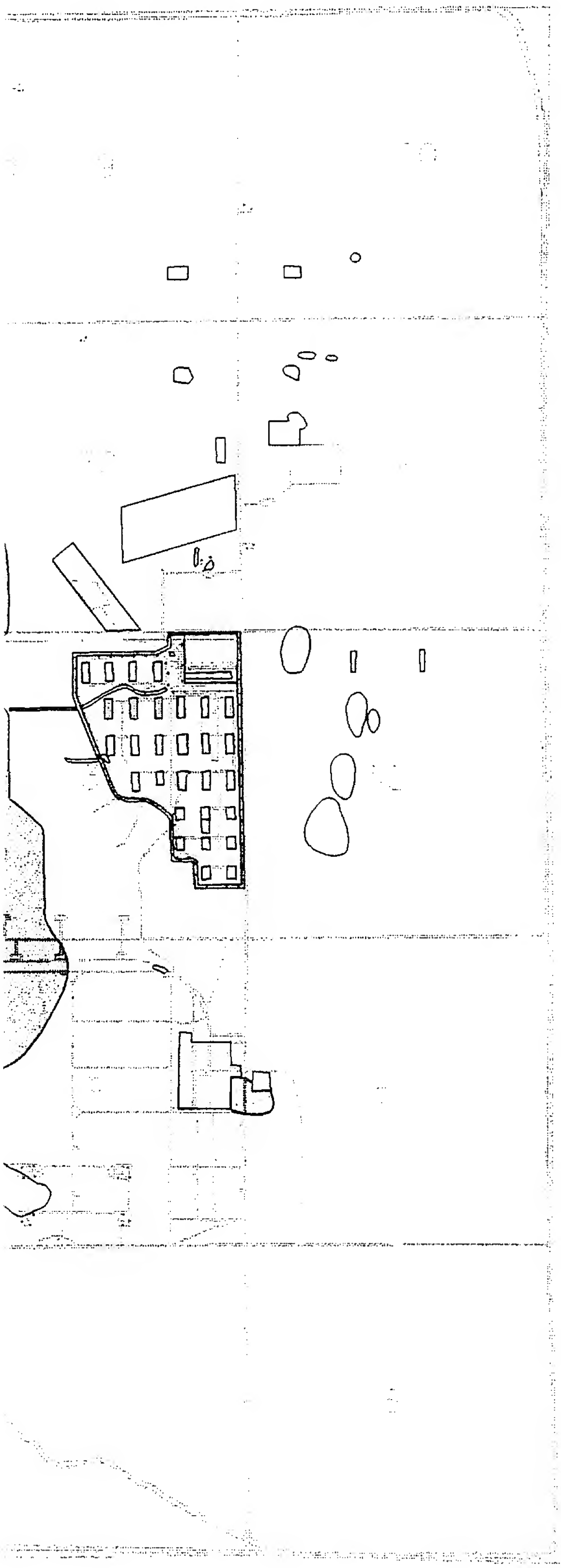
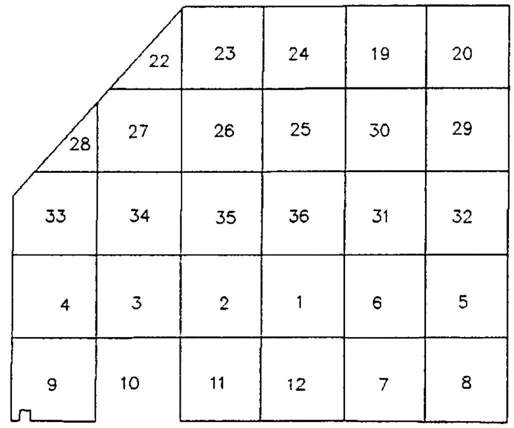




ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Surficial Soils Medium Group
SITES: NCSA-1g, Inferred Wind Dispersion
Surficial Soil Sampling Locations

Site Boundary

Buildings and Roads

Section Number

1500 0 1500 3000 FEET

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.0-1

Site Locations
Surficial Soils Medium Group

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated

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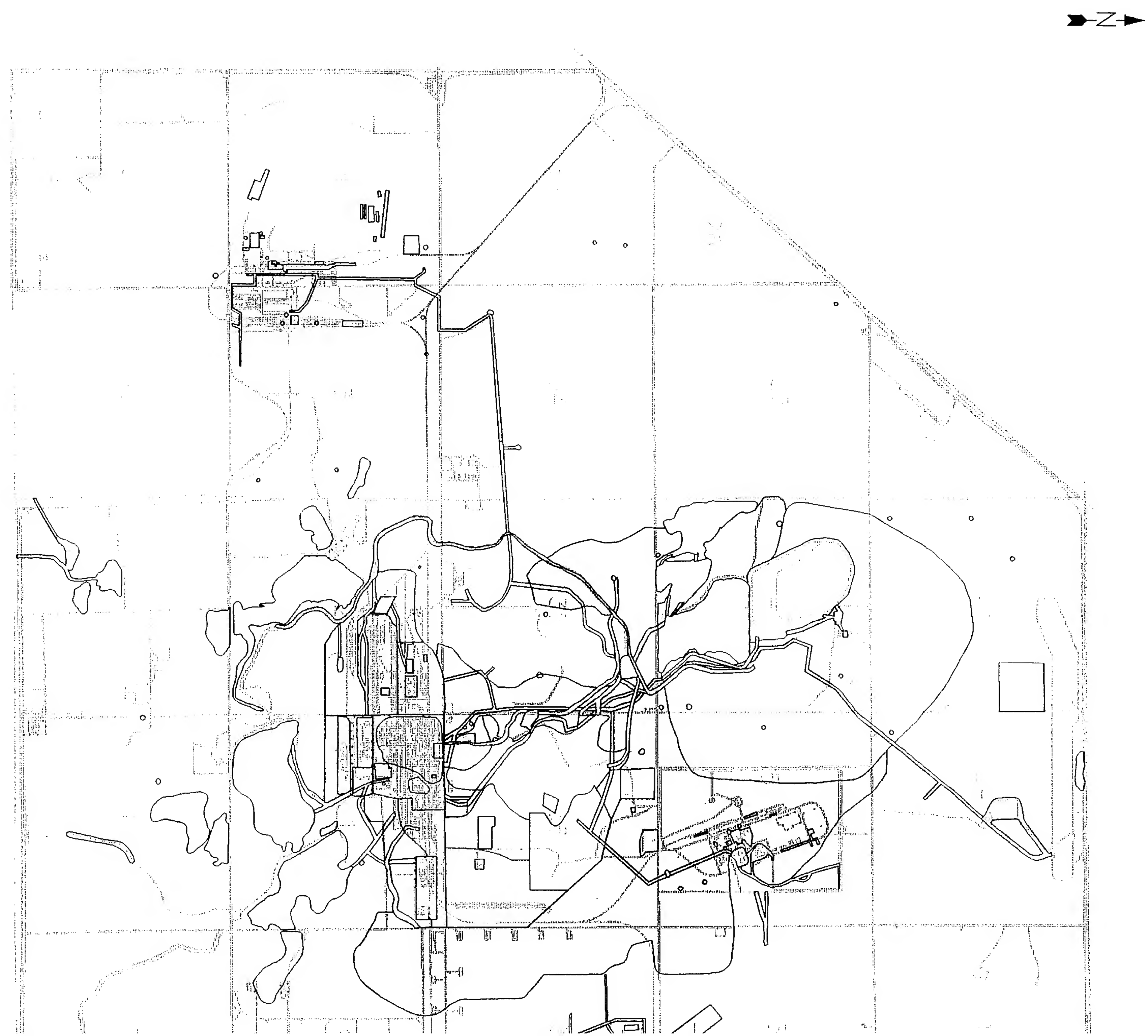
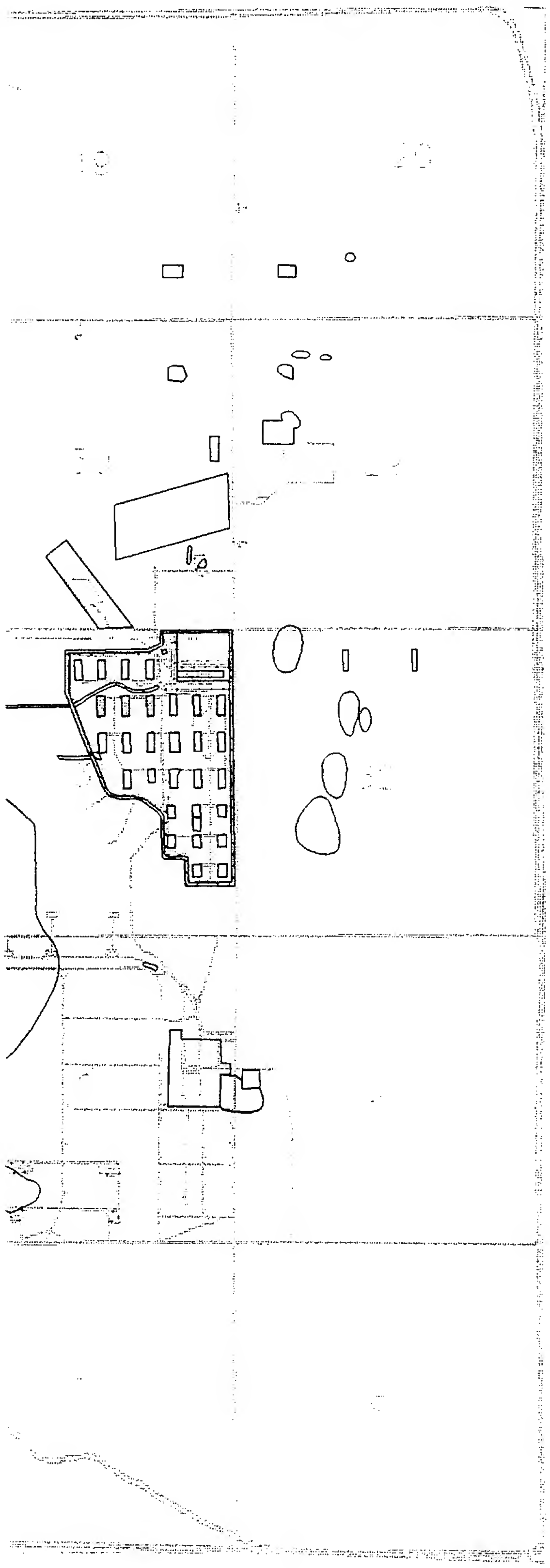
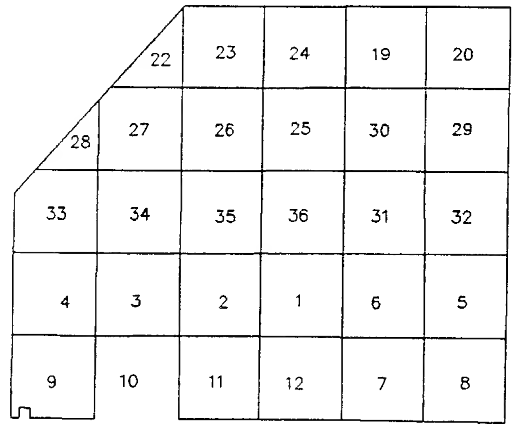




ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Biota Exceedance Area

Human Health Exceedance Area

Site Boundary

Buildings and Roads

Section Number

1500 0 1500 3000 FEET

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 8.1-1

Exceedance Areas
Surficial Soils Medium Group

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated

9.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE DITCHES/DRAINAGE AREAS MEDIUM GROUP

The Ditches/Drainage Areas Medium Group is composed of 13 sites that have varied disposal and release histories. These sites are located RMA wide (Figure 9.0-1). They are grouped together based on the potential risk they present to biotic receptors and their narrow configuration, which limits the implementability of some remedial alternatives.

The primary COCs present in this medium group are OCPs that exceed the Biota SEC only; the concentrations of these COCs are either below CRLs or the Biota SEC in the majority of the samples collected. Sites within this medium group are potential sources of surface-water contamination based on the potential pathways identified in the RISR (EBASCO 1992a/RIC 92017R01). Table 9.0-1 presents the characteristics of this medium group, including exceedance volumes and COCs.

In the DSA, alternatives were developed and screened based on the general characteristics of the medium group. For the DAA, individual subgroups were not developed for the 13 sites, so the retained alternatives apply to the Ditches/Drainage Areas Medium Group as a whole. The characteristics of the sites in this medium group–including contaminant types and contaminant concentrations, site configuration, and depth of contamination–were evaluated to determine whether modifications to the retained alternatives for the Ditches/Drainage Areas Medium Group would be appropriate. No modifications were made to the alternatives retained from the DSA for this medium group.

The following sections present the characteristics of the medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990), and the selection of a preferred alternative based on a comparative analysis of the alternatives. The preferred alternative is as follows:

- Alternative B5a—Excavation of biota exceedances and consolidation in Basin A as grading fill prior to capping of Basin A.

9.1 MEDIUM GROUP CHARACTERISTICS

The Ditches/Drainage Areas Medium Group is composed of sites CSA-2b (Parking Lot/Scrap Storage), ESA-6c (North Plants Drainage Ditch), NCSA-1c (Basin A to Basin B Ditches), NCSA-1d (Liquid Storage Pool), NCSA-1f (South Plants Drainage Ditches), NCSA-2d (Basin B to Basin C Ditch), NCSA-5d (Surface Drainage Canal), NCSA-8b (Sewage Treatment Plant), NPSA-8c (Miscellaneous Drainages), NPSA-9f (Isolated Detection), SSA-2a (Process Water Ditch System), SSA-2c (Overflow Basin and Ditch), and WSA-1f (Isolated Detection) (Figure 9.1-1). These ditches and drainages were primarily used to convey surface water away from other sites, including portions of North Plants and South Plants.

Table 9.1-1 provides a summary of contaminants, concentrations, and corresponding exceedance values for this medium group. As shown in this table, there are no human health exceedances; however, the Biota SEC are exceeded for maximum concentrations of OCPs, arsenic, and mercury. The average concentrations of all contaminants, except mercury, are also above the Biota SEC. These COCs were found at depths ranging up to 10 ft; however, the majority of contaminants were detected in the 0- to 1-ft depth interval. The frequency of detections in the boring samples is provided on Table 9.1-2. The Ditches/Drainage Areas Medium Group consists of 25,000 BCY of contaminated soils (Table 9.0-1). Figure 9.1-1 shows the exceedance areas for these sites.

The sites within this medium group are considered potential sources of surface-water contamination due to the direct contact between the contaminated soils and surface water. However, these sites are not considered sources of groundwater contamination because the ditches do not intersect the water table and only sporadically contain water. These sites do not encompass contaminated structures.

The sites within the Ditches/Drainage Areas Medium Group contain habitat that ranges in quality from high to low. Most of the high-quality habitat sites are located within the Bald Eagle Management Area. Therefore, the evaluation of alternatives for the medium group must consider

the impacts of alternatives on the habitat within these sites. The areas disturbed during most remedial alternatives are restored, unless the disturbed areas are revegetated specifically to exclude biota.

9.2 EVALUATION OF ALTERNATIVES

The six alternatives for the Ditches/Drainage Areas Medium Group vary in approach from no action to treatment. The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA.

Alternative 11: In situ thermal treatment (Surface Soil Heating) is not evaluated for this medium group since the equipment used for in situ heating cannot be implemented in an active drainage ditch. In addition, the containment alternative was modified from the DSA to account for consolidating the contaminated soils at Basin A instead of capping them in place.

9.2.1 Alternative B1: No Additional Action

Alternative B1: No Additional Action (Provisions of FFA) applies to the biota exceedance area of 25,000 SY. The exceedance volume of 25,000 BCY remains in place, and no action is taken to limit biota exposure to COCs or to reduce potential surface-water contamination resulting from contact with contaminated soils. Exceedance areas are monitored (an average of nine samples per year for the entire medium group) and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Table 9.2-1 presents the detailed evaluation of this alternative. Biota RAOs are not achieved under this alternative as untreated soils remain in place. Natural attenuation of contamination is ongoing, but the estimated time frame to achieve PRGs is longer than 30 years. The residual risk to biota is low due to the relatively low levels of contamination in the soils. The habitat and its range of value to biota is not changed. The total present worth cost of this alternative is $700,000. Table B3.3-B1 details costing for this alternative.

9.2.2 Alternative B2: Biota Management

Alternative B2: Biota Management (Exclusion, Habitat Modification) applies to the 25,000 SY of biota exceedance area in this medium group. The 25,000 BCY of contaminated soils remain in place, but exposure pathways to biota are interrupted. Biota access to exceedance areas is restricted by the installation of 27,000-ft of perimeter chain-link fencing. In addition, the existing habitat is modified by revegetating exceedance areas with grasses that are unappealing as habitat. Revegetation of 25,000 SY is accomplished over a 3-year period. No actions are taken to reduce potential surface-water contamination resulting from contact with contaminated soils. Long-term activities include maintaining fences, mowing, and spraying herbicide at selected locations in revegetated areas as well as monitoring for erosion and vegetation damage. Exceedance areas are also monitored (nine soil samples per year for the entire exceedance area). Five-year site reviews are performed to review the effectiveness of the alternative and to assess natural attenuation/degradation and potential migration of contaminants.

Table 9.2-2 presents the detailed evaluation of this alternative. Biota RAOs are achieved under this alternative in 3 years through access restrictions and interruption of biota exposure pathways. Long-term maintenance is required to ensure the effectiveness of the access controls. Soils with biota exceedances remain in place, although natural attenuation of contamination is ongoing. The residual risk is low due to the relatively low contaminant concentrations in the soils, but the potential impacts on surface water are not addressed through the installation of fencing and the modification of habitat. As part of the alternative, 25,000 SY of habitat is eliminated, but the impact on biota is minimal due to the linear nature of the sites and the relatively small area of disturbances. Some habitat mitigation, however, may be required. The total present worth cost of this alternative is $2,100,000. Table B3.3-B2 details the costing for this alternative.

9.2.3 Alternative B3: Landfill

Alternative B3: Landfill (On-Post Landfill) addresses 25,000 BCY of contaminated soils. The contaminated soils are excavated, transported to, and placed in a centralized on-post landfill. The landfill has the capacity for multiple cells and construction of the first cell and support facilities

requires 1 year. The excavations are backfilled to existing grade with borrow material from an on-post borrow area. Topsoil is obtained off post and placed on the backfilled area, and the area is revegetated. No maintenance activities are required at these sites because all soils with exceedances are removed. The borrow area is recontoured and revegetated to restore habitat.

Table 9.2-3 presents the detailed evaluation of this alternative. This alternative achieves Biota RAOs by transferring all contaminated soils to a containment cell. The potential for migration of contaminants to surface water at these sites is reduced and exposure pathways are interrupted because contaminated soil is removed and contained. The disposal of 25,000 BCY requires approximately 2 years, including 1 year for construction of the landfill. The impact to biota is minimal due to the linear nature of the sites and the relatively small areas of disturbance. Revegetating these sites with native grasses improves habitat quality. No site maintenance is necessary, although the landfill requires long-term monitoring (i.e., cover maintenance, leachate collection and treatment, and groundwater monitoring). The estimated present worth cost of this alternative is $1,600,000. Table B3.3-3 details the costing for this alternative.

9.2.4 Alternative B5a: Caps/Covers with Consolidation

Alternative B5a: Caps/Covers (Clay/Soil Cap) with Consolidation addresses 25,000 BCY of contaminated soils. The contaminated soils are excavated and transported to Basin A for consolidation with contaminated soils from other locations on RMA. These materials are used as grading fill to bring Basin A to design grade prior to containment with a clay/soil cap as described in Section 10.2.4. The site excavations are backfilled with borrow material from the on-post borrow area. Topsoil is obtained off post and placed on the backfilled area and the area is revegetated. The borrow area is recontoured and revegetated to restore habitat. No maintenance activities are required at these sites because all soils with exceedances are removed.

Table 9.2-4 presents the detailed evaluation of this alternative. The alternative achieves Biota RAOs through consolidation and containment of contaminated soils in Basin A. The residual risk achieves PRGs. The potential for migration of contaminants to surface water at these sites is

reduced and exposure pathways are interrupted because contaminated soils are removed. The consolidation and backfilling operations require 1 year to complete. The impact to biota is minimal due to the linear nature of the sites and the relatively small areas of disturbance. Revegetating these sites with native grasses after remediation improves improve habitat quality. No site maintenance is necessary, although the Basin A cap area requires long-term monitoring. The total estimated present worth cost of this alternative is $1,100,000. Table B3.3-5 details the costing for this alternative.

9.2.5 Alternative B6: Direct Thermal Desorption

Alternative B6: Direct Thermal Desorption (Direct Heating) treats 25,000 BCY of contaminated soils. The contaminated soils are excavated and transported to the centralized thermal desorption facility for treatment. For dry soils (i.e., moisture content of 10 percent or less), the thermal desorber operates at a rate of approximately 2,000 BCY/day. The thermal desorber treats and discharges soils at a temperature of 300°C based on a soils residence time of 30 minutes for dry soils. Section 4.5.24 discusses emission controls for the off gases associated with thermal desorption. Particulates from the scrubber blowdown amount to approximately 1 percent of the total solids feed. The blowdown particulate volume of 250 BCY is disposed in the on-post hazardous waste landfill. The treated soils are used as backfill in the original excavations and are covered with a layer of topsoil since thermal desorption destroys the natural organic content of the soils and makes them less conducive to revegetation. These sites are revegetated with native grasses, thereby improving habitat quality.

Table 9.2-5 presents the detailed evaluation of this alternative. This alternative achieves Biota RAOs, including the protection of surface water, since all contaminated soils are treated to remove or destroy the exceedance COCs. The residual risk achieves PRGs. The thermal desorption of 25,000 BCY of contaminated soil requires 3 years, including 2 years for construction and testing of the thermal desorption facility. The impact to biota is minimal due to the linear nature of the sites and the relatively small area of disturbance. Revegetating the topsoil with native grasses improves the habitat quality of the sites. No site maintenance is

necessary as the exceedance COCs are removed. The total estimated present worth cost of this alternative is $3,400,000. Table B3.3-6 lists the detailed cost estimate for this alternative.

9.2.6 Alternative B9: In Situ Biological Treatment

Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) applies to 25,000 SY of the ditches/drainage areas. This alternative achieves remediation to a depth of 12 to 18 inches by mimicking the agricultural practices of tilling, seeding, mulching, and fertilizing. As has been shown in many studies of agricultural soils, the concentrations of OCPs decrease with time when subjected to agricultural practices. In addition to decreasing contaminant concentration, this alternative minimizes the potential for surface-receptor contact with the existing contaminated surficial soils. Tilling and mixing of the soils is accomplished with traditional farm equipment or with a soil mixing device such as those commonly used for damaged roadbed reclamation.

The contaminants in this medium group are predominantly within the surface soils, but 9,400 BCY of exceedances are located at depths of 1 to 3 ft. Landfarm/agricultural practice is not capable of treating the contaminated soils at depth, so lower-quality vegetation is planted to make the habitat unappealing and thereby prevent exposure. The revegetation is accomplished over a 3-year period. Long-term activities include mowing and monitoring for erosion and vegetation damage. Since mechanisms of contaminant loss are not well understood and untreated soils remain in place, long-term monitoring is necessary until contaminant concentrations are below remediation goals. Monitoring is conducted (an average of 9 soil samples per year for the entire exceedance area) and 5-year site reviews are performed to assess the effectiveness of the alternative.

Table 9.2-6 presents the detailed evaluation of this alternative. The alternative is expected to be protective of human health and the environment as RAOs should be achieved through treatment and biota controls; however, since the mechanisms of degradation are not well understood, the time required to meet RAOs is difficult to determine. For costing purposes, RAOs were assumed

to be achieved in 3 years. As part of the alternative, habitat is eliminated for biota, but this impact is minimal due to the linear nature of the sites and the relatively small area of disturbance. Some habitat mitigation, however, may be required. The total present worth cost of this alternative is $600,000. Table B3.3-B9 details the costing for this alternative.

9.3 SELECTION OF PREFERRED ALTERNATIVE

The Ditches/Drainage Areas Medium Group contains 25,000 BCY of biota exceedance volume that occurs primarily in the upper 1 ft of soil. Due to the direct contact of contaminated soils with surface water, sites in this subgroup are considered potential sources of surface-water contamination. The contaminants that exceed the Biota SEC are mainly OCPs, along with arsenic and mercury. Aproximately 10 percent of the samples taken for this subgroup exceed the Biota SEC for an OCP (Table 9.12). Except for mercury, the average concentrations of exceedance contaminants within the biota exceedance volume are above the Biota SEC (Table 9.1-1). No contaminants in this subgroup exceed Human Health SEC and proper health and safety equipment and procedures can provide adequate worker protection during remedial activities.

Habitat quality within the medium group ranges from high to low. High-quality habitat sites are located within the Bald Eagle Management Area. Selection of the preferred alternative must include consideration of the impacts of remedial actions on habitat. Disturbed areas are restored and revegetated following remediation.

Alternative B1: No Additional Action does not achieve Biota RAOs and is therefore eliminated from further consideration as the preferred alternative. The five remaining alternatives, which include two treatment and three containment alternatives, achieve RAOs, and meet the two DAA threshold criteria: protection of human health and the environment and compliance with action-specific and location-specific ARARs; however, two alternatives do not completely comply with the location-specific ARARs as some sites are located in wetlands. Since all five alternatives satisfy the threshold criteria, the selection of the preferred alternative is based on differences in the five balancing criteria (Tables 9.2-1 through 9.2-6).

Alternative B2: Biota Management eliminates habitat at the sites within the medium group, requires 3 years to achieve RAOs, and entails long-term maintenance. Alternative B9: In Situ Biological Treatment has short-term impacts on habitat, but does not eliminate it. This alternative also requires 3 years to achieve RAOs. Alternative B3: Landfill and Alternative B5a: Caps/Covers with Consolidation are similar, as both include the excavation and containment of 25,000 BCY of contaminated soils, and cost $1,600,000 and $1,100,000, respectively. Alternative B6: Direct Thermal Desorption has the highest cost of alternatives developed for the Ditches/Drainage Areas Medium Group ($3,400,000).

The preferred alternative for the Ditches/Drainage Areas Medium Group is Biota Alternative B5a: Caps/Covers with Consolidation. This alternative is consistent with NCP guidance on engineering controls for low levels of contamination, and has one of the lowest costs ($1,100,000) in the range of effective remedial alternatives. By consolidating the soils in Basin A rather than capping them in place, the overall monitoring and maintenance costs at RMA are reduced. (Basin A is monitored following the installation of the cap/cover whether or not the Ditches/Drainage Areas soils are consolidated there.) In addition, the material excavated from the Ditches/Drainage Areas sites can provide part of the soil required to regrade Basin A for proper drainage prior to the installation of the cap. As a result, this alternative is considered cost effective for the remediation of the 25,000 BCY of low-level contaminated soils in this medium group. Selection of this alternative is predicated on the selection of Alternative 6f for the Basin A Medium Group.

Table 9.0-1 Characteristics of the Ditches/Drainage Areas Medium Group

Characteristic	Ditches/Drainage Areas Medium Group
Contaminants of Concern	
Human Health	none
Biota	OCPs, Hg, As
Exceedance Area (SY)	
Total	25,000
Human Health	0
Biota	25,000
Potential Agent	not applicable
Potential UXO	not applicable
Exceedance Volume (BCY)	
Total	25,000
Human Health	0
Organic	0
Inorganic	0
Principal Threat	0
Biota	25,000
Potential Agent	not applicable
Potential UXO	not applicable
Depth of Contamination (ft)	
Human Health	not applicable
Biota	0–10, Mostly 0–1

Table 9.1-1 Summary of Concentrations for the Ditches/Drainage Area Medium Group

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC (ppm)
Human Health Exceedance Volume					
None	not applicable	not applicable	not applicable	not applicable	not applicable
Biota Exceedance Volume					
Aldrin	BCRL-30	4.7	56	560	0.68
Dieldrin	BCRL-7	2.8	40	400	0.83
Endrin	BCRL-2	0.11	15	15,000	0.029
p,p,DDE	BCRL-6	1.6	130	1,300	0.20
p,pDDT	BCRL-2.5	0.7			
Arsenic	BCRL-250	37.3	530	5,300	16.5
Mercury	BCRL-1.9	0.72	470	470,000	0.99

1 Based on concentrations of contaminants of concern above SEC exceedance volume.

Table 9.1-2 Frequency of Detections for Ditches/Drainage Areas Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	276	237	85.9%	30	10.9%	9	3.3%	0	0.0%	0	0.0%
Benzene	88	87	98.9%	1	1.1%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	91	91	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	268	255	95.1%	13	4.9%	--	--	0	0.0%	0	0.0%
Chloroacetic Acid	30	30	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlorobenzene	91	90	98.9%	1	1.1%	--	--	0	0.0%	0	0.0%
Chloroform	91	91	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	276	245	88.8%	25	9.1%	6	2.2%	0	0.0%	0	0.0%
p,p,DDT	276	245	88.8%	30	10.9%	1	0.4%	0	0.0%	0	0.0%
Dibromochloropropane	212	209	98.6%	3	1.4%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	91	91	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	14	14	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	207	207	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	276	172	62.3%	86	31.2%	18	6.5%	0	0.0%	0	0.0%
Endrin	276	225	81.5%	25	9.1%	26	9.4%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	270	264	97.8%	6	2.2%	--	--	0	0.0%	0	0.0%
Isodrin	276	253	91.7%	23	8.3%	--	--	0	0.0%	0	0.0%
Methylene Chloride	87	81	93.1%	6	6.9%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	5	5	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	91	91	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Toluene	88	85	96.6%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	91	91	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	203	127	62.6%	66	32.5%	10	4.9%	0	0.0%	0	0.0%
Cadmium	169	153	90.5%	16	9.5%	--	--	0	0.0%	0	0.0%
Chromium	169	48	28.4%	121	71.6%	--	--	0	0.0%	0	0.0%
Lead	169	108	63.9%	61	36.1%	--	--	0	0.0%	0	0.0%
Mercury	283	218	77.0%	61	21.6%	4	1.4%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.

Table 9.2-1 Evaluation of Alternative B1: No Additional Action (Provisions of FFA) for the Ditches/Drainage Areas Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and the environment	Does not achieve Biota RAOs as untreated soils remain without controls implemented. Long-term reduction in toxicity of contaminants due to natural attenuation; surface-water impacts not reduced.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs as long-term monitoring and site reviews achieved.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Does not comply with location-specific ARARs. Ditches/Drainage Areas Medium Group located in wetlands and 100-year floodplain; biota may be impacted as no actions initiated under alternative.
c) Criteria, advisories and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. OCPs, arsenic, and mercury above Biota SEC remain in surface soils and continue to impact biota.
b) Adequacy and reliability of controls	b) No controls implemented. Site reviews and surface water monitoring required.
c) Habitat impacts	c) Habitat quality not improved. Existing low- to high-quality habitat not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction of contaminant volume or mobility except natural attenuation; 25,000 BCY of untreated soils remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or vapor emissions.
c) Environmental impacts of remedial action	c) Minimal environmental impacts. Existing high- to low-quality habitat not impacted by remedial alternative; migration of contaminants to surface water not reduced.
d) Time until RAOs are achieved	d) >30 years. Natural attenuation only process for contaminant reduction.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Monitoring services readily available.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $700,000
d) Total	d) $700,000

Table 9.2-2 Evaluation of Alternative B2: Biota Management (Exclusion, Habitat Modification) for the Ditches/Drainage Areas Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and the environment	Protective of human health and environment. RAOs achieved as biota exposure pathways interrupted through access restrictions and biota controls; surface-water impacts not reduced.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs as access adequately controlled and site reviews conducted; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Does not comply with location-specific ARARs as Ditches/Drainage Areas Medium Group located in wetlands and 100-year floodplain; surface water controls could be constructed to modify 100-year floodplain.
c) Criteria, advisories and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. OCPs, arsenic, and mercury above Biota SEC remain in place; biota controls of fencing and cultivation of lower-quality habitat reduce biota exposure.
b) Adequacy and reliability of controls	b) Adequate controls. Installation of fencing and habitat modifications reduce biota exposure; controls adequate for small area; long-term maintenance, site review, surface-water monitoring, and monitoring of wildlife exclusion required.
c) Habitat impacts	c) Habitat quality eliminated. Biota controls consisting of fencing and cultivation of lower-quality habitat eliminate habitat for biota.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction of contaminant volume or mobility except by natural attenuation for 25,000 BCY of untreated soils; biota exposure pathways interrupted by fencing and biota controls.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Exposure controls reversible if fencing and biota controls fail.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative. Contaminants remain in place.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during fence installation and cultivation of lower-quality habitat.
b) Protection of community during remedial action	b) Protective of community. Dust and vapor emissions not anticipated.
c) Environmental impacts of remedial action	c) Moderate environmental impacts. Moderate impact on habitat during installation due to elimination of habitat; potential migration of contaminants to surface water not reduced.
d) Time until RAOs are achieved	d) 3 years. Installation of perimeter fencing within several months but cultivation of lower-quality habitat requires 3 years; natural attenuation of untreated soils ongoing.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably maintained thereafter; additional remedial actions easily undertaken for soils left in place.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment readily available for fence installation and habitat modifications.
7. Present worth costs	
a) Capital	a) $870,000
b) Operating	b) $9,000
c) Long-term	c) $1,300,000
d) Total	d) $2,100,000

Table 9.2-3 Evaluation of Alternative B3: Landfill (On-post Landfill) for the Ditches/Drainage Areas Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and the environment	Protective of human health and environment. Achieves RAOs through containment; contaminated soils contained in on-post landfill preventing biota exposure; surface-water impacts not reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-8)	a) Complies with action-specific ARARs including state regulations on landfill siting, design and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as wetlands restored after excavation and permanent structures not constructed in 100-year floodplain; landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 25,000 BCY untreated soil contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls of landfill.
c) Habitat quality	c) Habitat quality improved at site. Revegetation of disturbed areas improves existing low- to high-quality habitat at site but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Exposure pathways interrupted and mobility of contaminants reduced through containment of 25,000 BCY in on-post landfill.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation and transportation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial action	c) Minimal environmental impacts. Minimal impact to biota due to linear nature of sites, and small areas of disruption; migration of contaminants to surface water reduced.
d) Time until RAOs are achieved	d) 2 years. Consolidation of 25,000 BCY feasible within 1 year after 1 year for construction of on-post landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cells monitored; additional remedial actions require removal of landfill cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Equipment, specialists, and materials (including clay) readily available for construction of landfill; landfills well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $500,000
b) Operating	b) $1,000,000
c) Long-term	c) $100,000
d) Total	d) $1,600,000

Table 9.2-4 Evaluation of Alternative B5a: Caps/Covers (Clay/Soil Cap) with Consolidation for the Ditches/Drainage Areas Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and the environment	Protective exposure of human health and environment. Achieves RAOs through containment; contaminated soils above Biota SEC excavated and consolidated in Basin A for containment with clay/soil cap preventing exposure; surface-water impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-5)	a) Complies with action-specific ARARs regarding construction of RCRA covers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as wetlands restored after excavation and permanent structures not constructed at sites in 100-year floodplain; Basin A not located in wetlands or 100-year floodplain.
c) Criteria, advisories and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 25,000 BCY of soil consolidated and contained in Basin A with clay/soil cap.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for Basin A; high confidence in engineering controls of clay/soil cap in Basin A.
c) Habitat impacts	c) Habitat quality improved at site. Revegetation of disturbed existing low- to high-quality habitat improves habitat.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Exposure pathways interrupted and mobility of contaminants reduced through consolidation of 25,000 BCY of contaminated soils in Basin A and installation of clay/soil cap in Basin A.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if Basin A cap degrades of leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation and transportation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial action	c) Minimal environmental impacts. Minimal impact to biota due to linear nature of sites and small areas of disruption. Migration of contamination to surface water reduced.
d) Time until RAOs are achieved	d) 1 year. Consolidation of 25,000 BCY in Basin A feasible within 1 year.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative implemented within required time frame and cap/cover reliably maintained thereafter; additional remedial actions require removal of cap/cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of cap/cover design and construction regulations.
c) Availability of services and materials	c) Readily implemented. Equipment, specialists, and materials readily available for consolidation and clay/soil cap construction; clay/soil caps well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $1,100,000
c) Long-term	c) $0
d) Total	d) $1,100,000

Table 9.2-5 Evaluation of Alternative B6: Direct Thermal Desorption (Direct Heating) for the Ditches/Drainage Areas Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and the environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to OCP detection levels and inorganics reduced below Biota SEC; blowdown solids placed in on-post landfill; surface-water impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-5)	a) Complies with action-specific ARARs including state regulations on air emissions sources, treatment system and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as wetlands restored after excavation and permanent structures not constructed at sites in 100-year floodplain; thermal desorption facility and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 25,000 BCY thermally desorbed and returned to site as backfill; approximately 1% of solids feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Backfill monitoring not required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves low- to high-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 25,000 BCY thermally desorbed to degrade OCPs and remove mercury.
b) Degree and quantity of TMV reduction	b) OCPs reduced to below detection levels (>99.99% destruction removal efficiency). TMV of OCPs eliminated; mercury removed below Biota SEC; arsenic reduced below Biota SEC following solids blending as a pre-treatment and limited volatilization during thermal desorption (20% to 30%); scrubber blowdown solids from off-gas treatment equipment with mercury, arsenic, and salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible.
d) Type and quantity of treatment residuals	d) 250 BCY of blowdown solids with mercury, arsenic, and salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation, transportation and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation; vapor emission associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial action	c) Minimal environmental impacts. Minimal impact to biota because of linear nature of sites and small areas of disruption; migration of contaminants to surface water reduced.
d) Time until RAOs are achieved	d) 3 years. Excavation and treatment of 25,000 BCY feasible within 1 year after 2 years for construction for thermal desorption facility and landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cell monitored.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment unit and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers; equipment, specialists, and materials readily available for construction of landfill; thermal desorbers and landfills well demonstrated at full scale.

Table 9.2-5 Evaluation of Alternative B6: Direct Thermal Desorption (Direct Heating) for the Ditches/Drainage Areas Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and the environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to OCP detection levels and inorganics reduced below Biota SEC; blowdown solids placed in on-post landfill; surface-water impacts reduced.
7. Present worth costs	
a) Capital	a) $650,000
b) Operating	b) $2,700,000
c) Long-term	c) $1,000
d) Total	d) $3,400,000

Table 9.2-6 Evaluation of Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Ditches/Drainage Areas Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and the environment	Protective of human health and environment. Achieves RAOs through treatment and interruption of exposure pathways through biota controls; surface-water impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-5)	a) Complies with action-specific ARARs including state regulations on air emissions sources; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Does not comply with location-specific ARARs as Ditches/Drainage Areas Medium Group located in wetlands and 100-year floodplain.
c) Criteria, advisories and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 25,000 SY landfarmed to reduce TMV; 9,400 BCY of untreated soils remain at depths 1 to 3 ft below surficial soils.
b) Adequacy and reliability of controls	b) No controls implemented. Site reviews and long-term monitoring required.
c) Habitat impacts	c) Habitat quality eliminated. Biota controls of cultivating lower-quality habitat eliminates habitat for biota.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) Landfarm/agricultural practice reduce TMV of surficial soils; 9,400 BCY of subsurface soils not treated except by natural attenuation.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) TMV reduction by landfarm/agricultural practice irreversible. Exposure controls reversible if habitat controls fail.
d) Type and quantity of treatment residuals	b) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during in situ treatment and cultivation of lower-quality habitat.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial action	c) Moderate environmental impacts. Moderate impact to biota as habitat eliminated; migration of contaminants to surface water reduced.
d) Time until RAOs are achieved	d) 3 years. Treatment of 25,000 SY and cultivation of lower-quality habitat feasible in 4 years; natural attenuation of untreated soils ongoing.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative implemented within required time frame and reliably maintained thereafter; additional remedial action easily undertaken.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Readily implemented. Equipment, specialists, and materials readily available for landfarm/agricultural practice and habitat modifications.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $19,000
c) Long-term	c) $580,000
d) Total	d) $600,000

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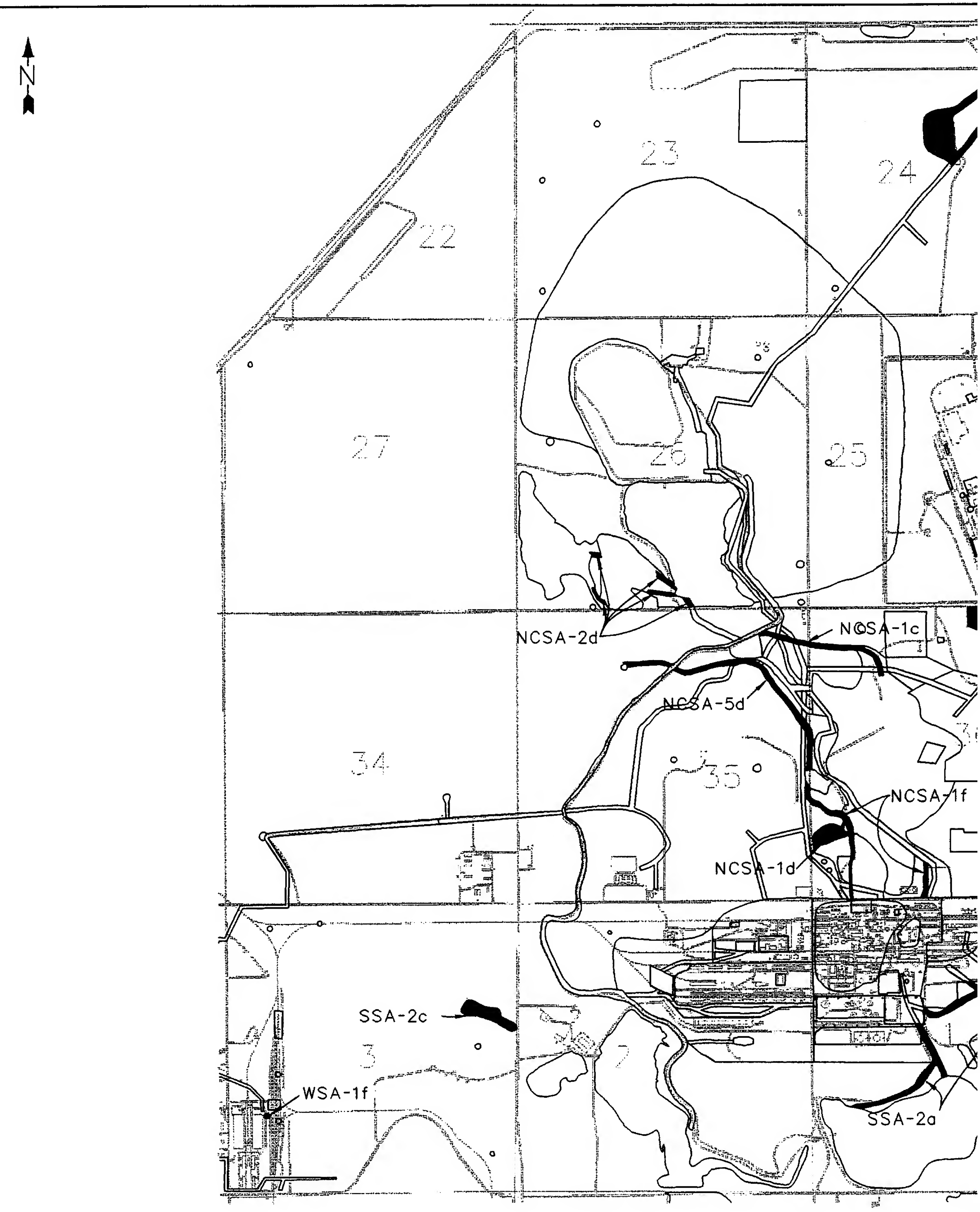
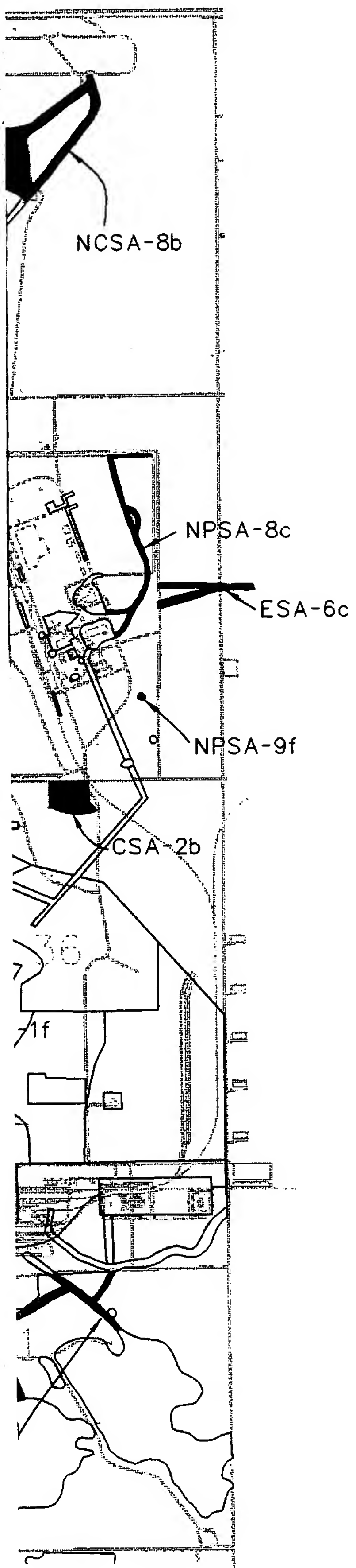
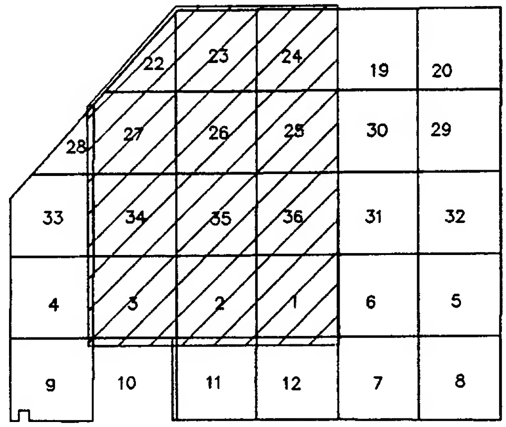




ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Ditches/Drainage Areas Medium Group
Sites: CSA-2b, Parking Lot/Scrap Storage
ESA-6c, Ditch from North Plants
NCSA-1c, Basin A to Basin B Ditch
NCSA-1d, Liquid Storage Pool
NCSA-1f, South Plants Drainage Ditches
NCSA-2d, Basin B to Basin C Ditch
NCSA-5d, Surface Drainage Canal
NCSA-8b, Sewage Treatment Plant
NPSA-8c, Miscellaneous Drainage
NPSA-9f, Isolated Detection
SSA-2a, Process Water Ditch System
SSA-2c, Overflow Basin and Ditch
WSA-1f, Isolated Detection

Site Boundary

Buildings and Roads

2 Section Number

1100 0 1100 2200 FEET

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 9.0-1

Site Locations
Ditches/Drainage Areas Medium Group

Rocky Mountain Arsenal.
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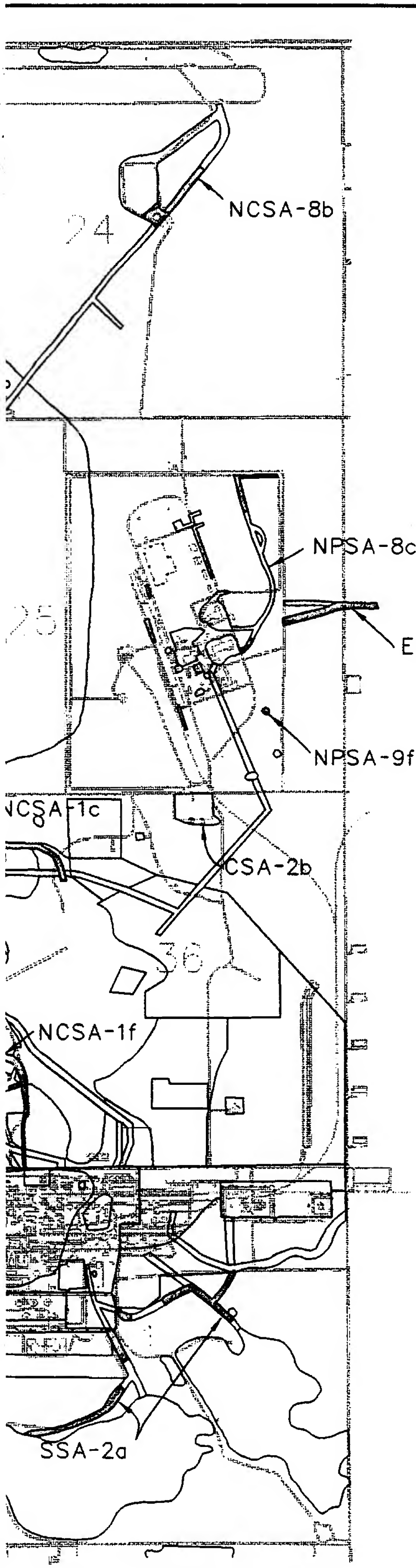
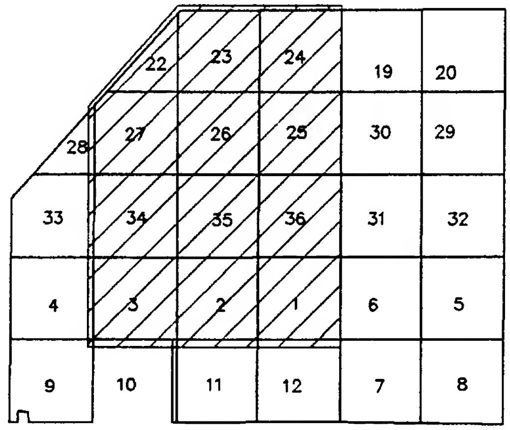


ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Biota Exceedance Area

Site Boundary

Buildings and Roads

2 Section Number

1100 0 1100 2200 FEET

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U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 9.1-1

Exceedance Areas
Ditches/Drainage Areas Medium
Group

Rocky Mountain Arsenal.
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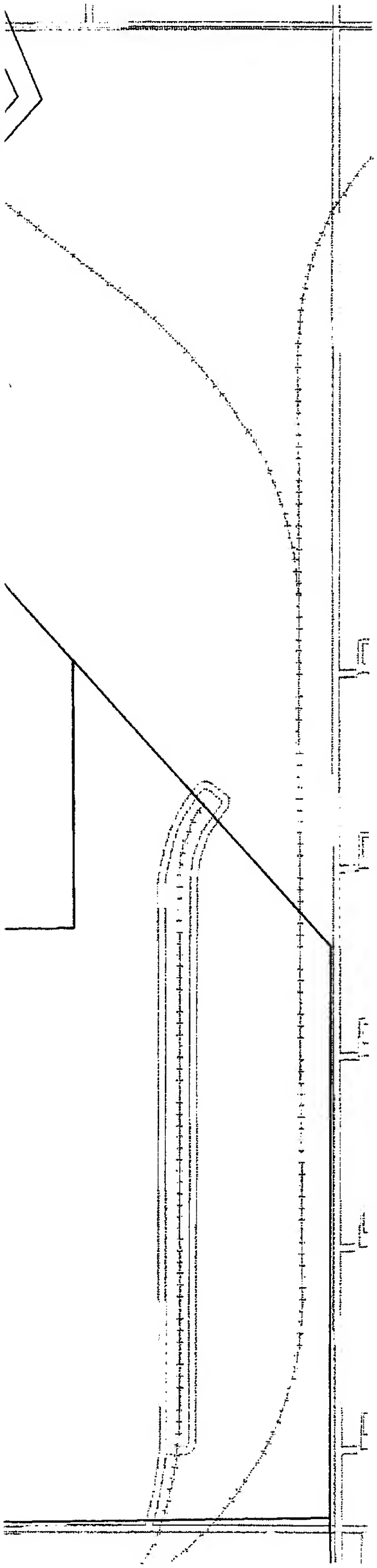
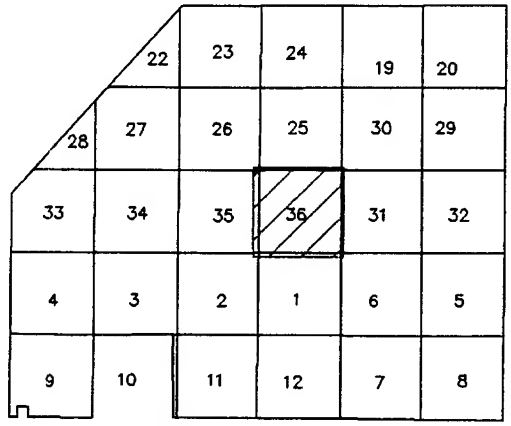


ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Basin A Medium Group
SITES: NCSA-1a, Basin A
NCSA-1e, Burn Site

Site Boundary

Buildings and Roads

36 Section Number

300 0 300 600 FEET

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U.S. Army Program Manager
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FIGURE 10.0-1

Site Locations
Basin A Medium Group

Rocky Mountain Arsenal.
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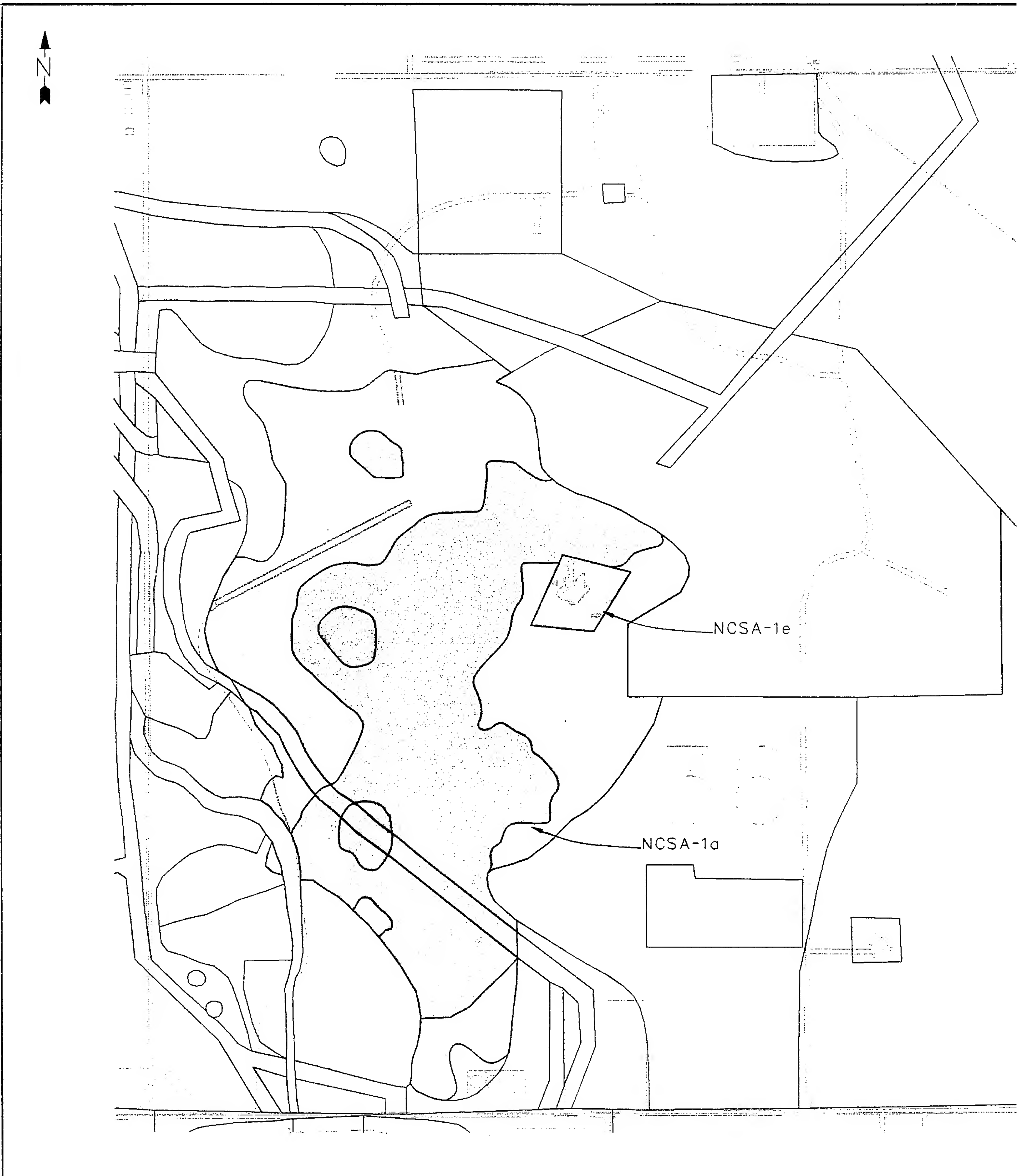
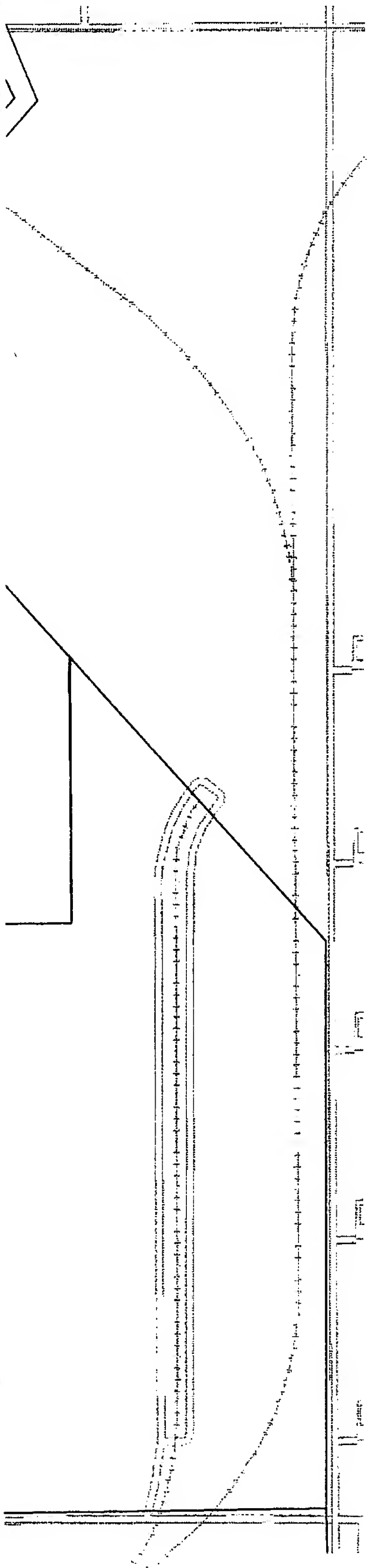
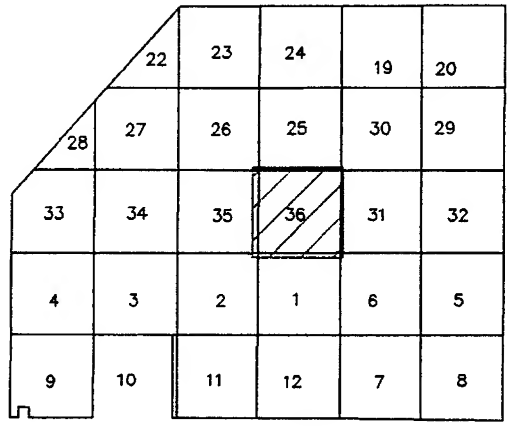




ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Biota Exceedance Area

Human Health Exceedance Area

Principal Threat Exceedance Area

Site Boundary

Buildings and Roads

36 Section Number

300 0 300 600 FEET

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FIGURE 10.1-1

Exceedance Areas
Basin A Medium Group

Rocky Mountain Arsenal.
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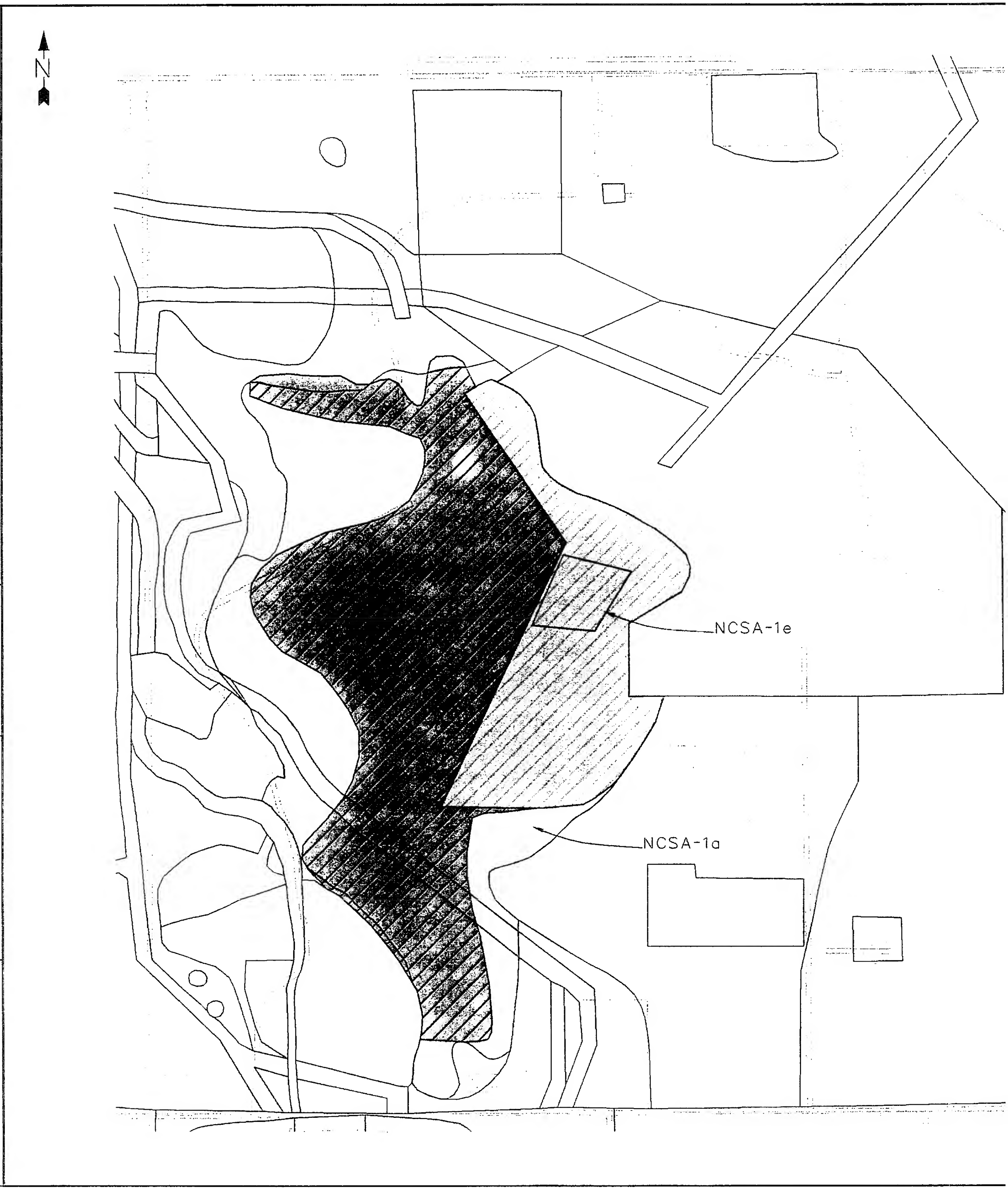
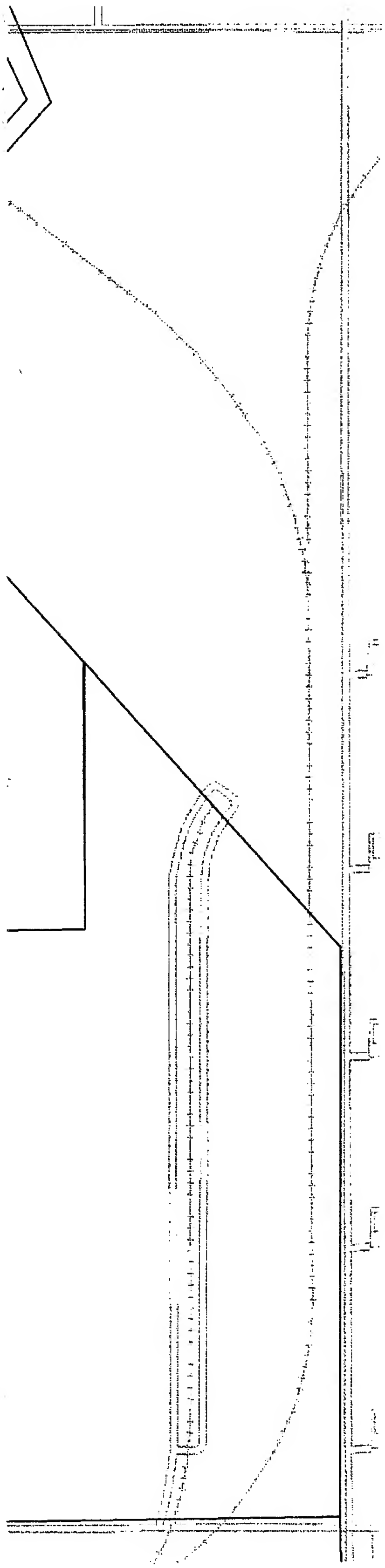
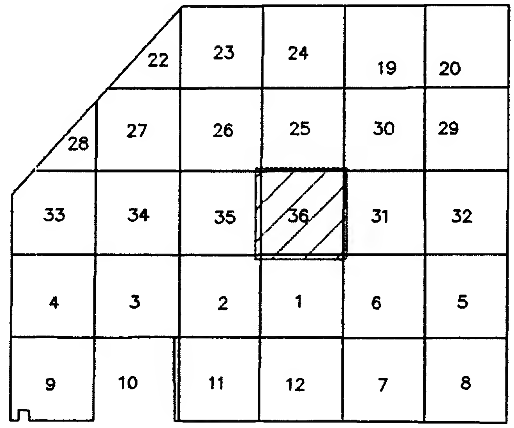




ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Human Health/Biota Exceedance Area

Potential Agent Presence Area

Potential Agent and UXO Presence Area

Site Boundary

Buildings and Roads

36 Section Number

300 0 300 600 FEET

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for Rocky Mountain Arsenal

FIGURE 10.1-2

Potential Agent/UXO Presence Areas
Basin A Medium Group

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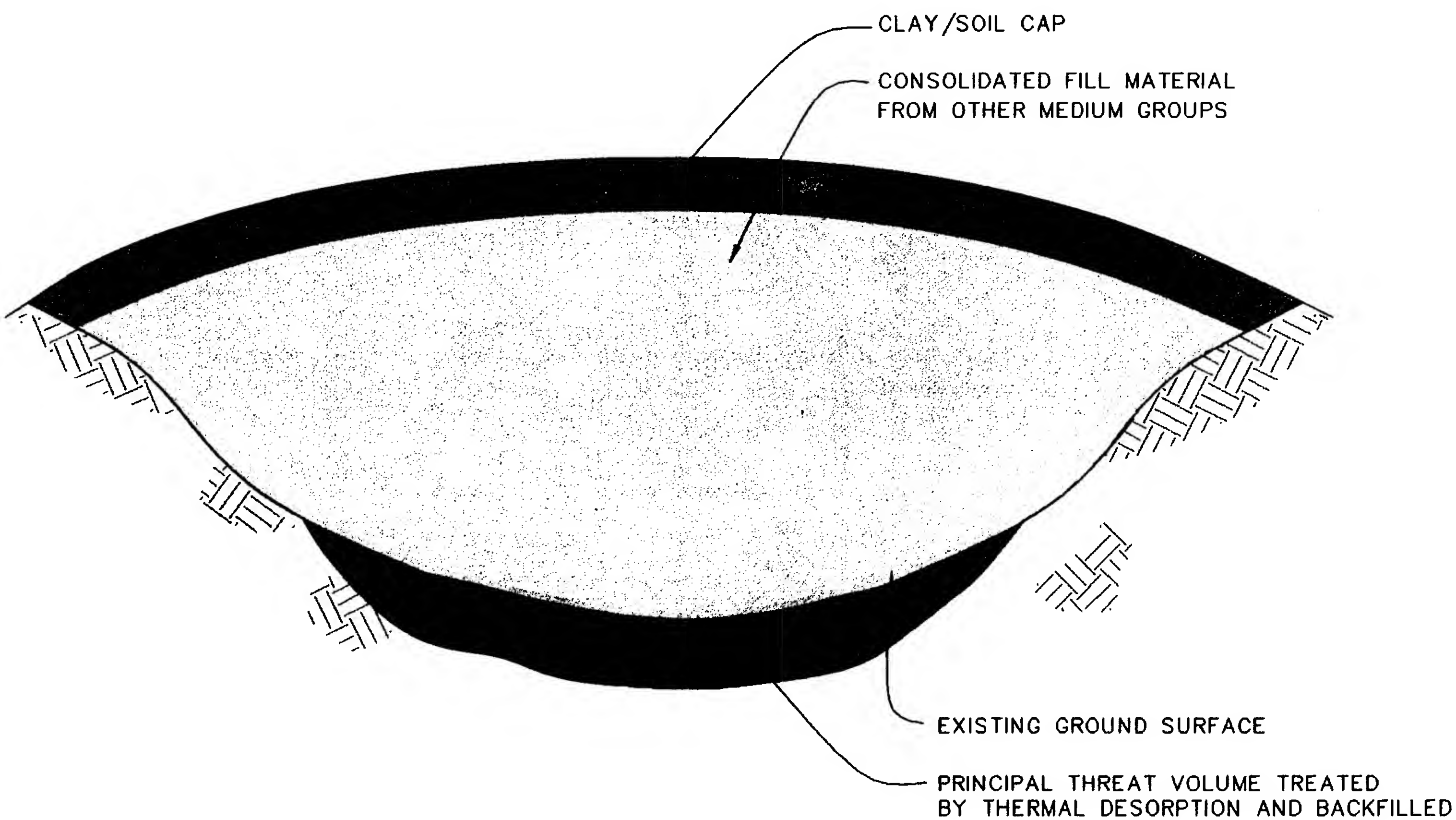


Perpared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 10.2-1
Schematic of Alternatine 6f for Basin A Medium Group

Ebasco Services Incorporated
December 1992

10.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE BASIN A MEDIUM GROUP

The Basin A Medium Group is composed of two sites that are within the Basin A high-water line (Figure 10.0-1). Basin A is considered a distinct medium group from the other basins at RMA because of the potential presence of agent and UXO. Manufacturing wastewater effluent, which contained a combination of organic and inorganic contaminants, was historically disposed into Basin A.

The primary Human Health and Biota COCs in this medium group are OCPs and arsenic. Waste disposal in Basin A has resulted in elevated salt concentrations in the soil due to the high chloride content. Site NCSA-1a (Basin A) contains high levels of contamination, and a part of the site is considered a principal threat area. (See Section 1.4.3 for a discussion of principal threats.) Portions of the Basin A Medium Group contain mercury above Biota SEC, but not above Human Health SEC, and some areas of the medium group potentially contain agent and/or UXO. The two sites within this medium group are also potential sources of groundwater and surface-water contamination based upon the migration pathways identified in the RISR (EBASCO 1992a/RIC 92017R01). Table 10.0-1 presents the characteristics of this medium group, including exceedance volumes and COCs, and Appendix A contains the calculation of exceedance volumes and areas for the Basin A Medium Group.

In the DSA, alternatives were developed and screened based on the general characteristics of the medium group. Individual subgroups were not developed during the DAA, so the retained alternatives apply to the medium group as a whole. The characteristics of the sites in this medium group—including contaminants and contaminant concentrations, site configuration, and depth of contamination—were reviewed to determine whether changes to the retained alternatives for the Basin A Medium Group would be appropriate. As a result, the alternatives for the medium group were modified from the DSA to treat the principal threat areas that were identified (see Section 10.2).

The following sections present the characteristics of the medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990), and the selection of a preferred alternative based on a comparative analysis of the alternatives. The preferred alternative is as follows:

- Alternative 6f—Direct thermal desorption of principal threat volumes and containment of remaining human health, biota, agent presence, and UXO presence exceedance areas through the installation of a clay/soil cap.

10.1 MEDIUM GROUP CHARACTERISTICS

The Basin A Medium Group is composed of sites NCSA-1a (Basin A) and NCSA-1e (Burn Site) (Figure 10.0-1). These sites, consisting of soils within the high-water line of Basin A, received and retained manufacturing effluent from South Plants via the Lime Settling Basins. Site NCSA-1e was used to incinerate munitions and trash from South Plants. Figure 10.1-1 illustrates both the distribution of the human health and biota exceedance areas in this medium group as well as the locations of the principal threat areas, and Figure 10.1-2 presents the location of the potential agent and UXO presence areas relative to the exceedance areas.

Table 10.1-1 provides a summary of contaminants, concentrations, and corresponding exceedance values for the medium group, which contains 830,000 BCY of contaminated soils (Table 10.0-1) while Table 10.1-2 lists the frequency of detections for the Basin A Medium Group. The table shows that maximum concentrations of OCPs, arsenic, and chromium exceed the Human Health SEC. The maximum concentration of chlordane (270 ppm) also exceeds the principal threats criteria (10^{-3} excess cancer risk, HI of 1,000) in approximately 4,600 BCY (Table 10.0-1). Biota exceedances are found between 0 and 10 ft below ground surface outside of the human health exceedance area (Figure 10.1-1). The majority of the biota exceedance volume is found between the 0- and 8-ft depth interval. The human health COCs are found in the 0- to 10-ft depth interval. The Biota SEC are exceeded by the maximum concentrations of OCPs, arsenic, and mercury. Average concentrations of most COCs detected are also above Biota SEC. In addition, both sites in this medium group may contain agent and/or UXO. Site NCSA-1e

contains a black sludge layer detected at approximately 2- to 5-ft below ground surface that may contain munitions.

The Basin A Medium Group can be subdivided into three regions based on differences in contaminant types and concentrations. The eastern region is characterized by high concentrations of OCPs, arsenic, and chromium above the Human Health SEC. The southern region is characterized by high concentrations of OCPs, chlordane, and dichlorodiphenyl trichloroethane (p,p,DDT) above the Human Health SEC. The northern region is characterized by low concentrations of OCPs, arsenic, and mercury and the presence of chlordane above the Human Health SEC. Portions of these three regions potentially contain agent, but only the eastern region potentially contains UXO (Figure 10.1-2).

The area within the Basin A Medium Group was assigned a poor habitat value based on the vegetation types encountered and the fact that much of the area has been disturbed by waste disposal activities. The areas that are disturbed due to remediation are to be revegetated with native grasses in accordance with a refuge management plan following remediation, so the overall habitat value is improved through remedial actions. However, burrowing animals are excluded from these areas for alternatives involving containment with a cap/cover.

Both of the sites within the Basin A Medium Group have been identified as sources of a contaminated groundwater plume. The plume occurs in the unconfined aquifer and follows the Basin A Neck paleochannel to the northwest where it is intercepted and treated by the Basin A Neck IRA treatment system. Groundwater alternatives are currently being evaluated for the Basin A Plume Group in the Water DAA (Section 7), and soils containment or excavation alternatives need to be coordinated with alternatives developed for the water medium. In addition soils alternatives that require dewatering must be coordinated with water alternatives. For example, the need for a separate soils dewatering system may be reduced depending on the schedule for groundwater remediation.

10.2 BASIN A MEDIUM GROUP EVALUATION OF ALTERNATIVES

The nine alternatives for this medium group vary in approach from no action to containment and treatment. The retained alternatives from the DSA were modified to account for the treatment of principal threat volumes. In addition, the containment alternative was modified by the removal of the slurry walls proposed in the DSA based on the results of groundwater modeling performed during the DAA. The removal of FC2A as a COC results in the withdrawal of Alternative 9: Direct Soil Washing. This alternative was retained in the DSA solely for treating FC2A and was not evaluated for the DAA since FC2A is no longer considered a COC. Solvent washing was screened out in the DSA in favor of thermal desorption based on effectiveness and cost considerations; however, ongoing treatability studies have demonstrated the effective treatment of soils contaminated with OCPs and appear to indicate that soils with agent can be treated to a 3X level. As such, solvent washing offers the potential for treating soils with both OCPs and agent, and Alternative 8: Direct Soil Washing; Direct Solidification has been reintroduced into the DAA for Basin A. The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA. Each alternative for the Basin A Medium Group is comprised of an alternative to address soils with human health exceedances (which is always listed first), an alternative to address soils with biota exceedance areas (the "B" alternative), and alternatives for soils with potential prescence of agent (the "A" alternative) and UXO (the "U" alternative).

10.2.1 Alternative 1/B1/A1/U1: No Additional Action

The No Additional Action alternative for Basin A, consisting of Alternative 1: No Additional Action (Provisions of FFA), along with Alternative B1: No Additional Action (Provisions of FFA), Alternative A1: No Additional Action (Provisions of FFA), and Alternative U1: No Additional Action (Provisions of FFA), applies to all 560,000 SY of exceedance areas in the Basin A Medium Group. The 830,000 BCY of total exceedance volume (including human health, biota, UXO, and agent exceedance volumes) remain in place. No action is taken to reduce human or biota exposure to COCs or to reduce potential groundwater or surface-water contamination from sites in this group. Long-term monitoring of exceedance areas is conducted

(an average of 65 samples per year) and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Table 10.2-1 presents the detailed evaluation of this alternative. Human Health and Biota RAOs are not achieved under this alternative as untreated soils remain in place without any controls to prevent exposure. No action is undertaken for potential agent and UXO areas and there are continued impacts on groundwater quality. The residual risk for human health and biota exposure is high due to the high levels of contamination in the soil. Natural attenuation is ongoing, but the estimated time frame to achieve PRGs is much longer than 30 years. The poor-quality habitat at the sites is not improved. Costs associated with soil monitoring and site reviews result in a total estimated present worth cost of $4,000,000. Table B4.1-1 details the costing for this alternative.

10.2.2 Alternative 1a/B1/A1/U1: Direct Thermal Desorption of Principal Threat Volume; No Additional Action

Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA), along with Alternative B1: No Additional Action (Provisions of FFA), Alternative A1: No Additional Action (Provisions of FFA), and Alternative U1: No Additional Action (Provisions of FFA), involves treatment of 4,600 BCY of principal threat volumes in the Basin A Medium Group. This area is cleared of UXO using geophysics and is screened for the presence of agent prior to the excavation of the principal threat volumes. Any identified UXO is excavated, packaged, and transported to an off-post Army facility for demilitarization in accordance with Alternative U4: Detonation; Incineration/Pyrolysis as discussed in Section 4.3.5. Soils with identified agent contamination are treated by incineration in accordance with Alternative A4: Incineration/Pyrolysis as described in Section 4.4.4. During excavation, daily soil cover or a plastic liner is placed over the excavated areas to minimize the release of odors and volatile contaminants.

The principal threat volume of 4,600 BCY is excavated and hauled to a centralized thermal desorption facility. The soils are assumed to be saturated (20 percent water) due to the high water table in Basin A. Saturated soils are processed through the desorber at a rate of approximately 1,300 BCY/day with an operating temperature of 300°C and a solids residence time of 50 minutes. The processing rate for thermal desorption decreases as the water content of the soil increases due to the additional heat required to evaporate the water from the soil prior to desorption of the contaminants. Section 4.6 discusses emission controls for off gases from the thermal desorber. Particulates from quench blowdown amount to approximately 1 percent of the total solids feed. This particulate volume of 46 BCY is trucked to the on-post landfill for disposal. Treated soils are returned to the site excavation and backfilled. Since thermal desorption removes the organic carbon in the soils, topsoil is placed over the backfilled areas before revegetation with native grasses to restore habitat.

The 540,000 SY of remaining soils with human health, biota, UXO, and agent exceedances in the Basin A Medium Group fall under the no additional action part of the alternative. The remaining volume of 830,000 BCY of contaminated soils remain in place without the initiation of any controls. No action is taken in these areas to reduce human or biota exposure to COCs or to reduce potential groundwater contamination. The remaining soils exhibit moderate residual risk for human health based on average concentrations as the Human Health SEC are exceeded only by the average concentration of chlordane. Residual risk is still present for biota. Long-term monitoring of exceedance areas is conducted (an average of 65 samples per year) and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Table 10.2-2 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. Human Health and Biota RAOs are not achieved under this alternative as 830,000 BCY of contaminated soils remain on post without treatment or controls. Since no action is undertaken for potential agent or UXO (other than in the principal threat areas), the potential physical and health hazards from agent and UXO are not addressed. Potential migration of contaminants to

groundwater is not reduced, although the principal threat volume is eliminated as a possible source. Natural attenuation is ongoing, but the estimated time frame to achieve PRGs is much longer than 30 years. The residual risk is moderate as the highest levels of contamination in principal threat areas are treated. The time frame for completion of the alternative is 3 years (2 years for construction and testing of the centralized thermal desorption facility and approximately 1 year for treatment). The overall poor-quality habitat is not changed except in the revegetated principal threat areas. The total estimated present worth cost of this alternative is $4,600,000. Table B4.1-1a details the costing for this alternative.

10.2.3 Alternative 3/B3/A4/U4: Landfill

Alternative 3: Landfill (On-Post Landfill), combined with Alternative B3: Landfill (On-Post Landfill), Alternative A4: Incineration/Pyrolysis (Rotary Kiln), and Alternative U4: Detotation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration), consists of the excavation and disposal of 830,000 BCY of contaminated soils in a centralized on-post landfill. Approximately 420,000 SY of Basin A potentially contain agent, which are cleared in accordance with Alternative A4, and 130,000 SY of soils potentially contain UXO, which are cleared in accordance with Alternative U4.

Prior to excavation, the areas with potential UXO are cleared using geophysics to identify locations containing UXO. The UXO are excavated, packaged, and transported to an off-post Army facility for demilitarization (Alternative U4). Approximately 43,000 BCY of surficial debris and soils associated with UXO clearance are removed and landfilled. Prior to excavation, the soils are also sampled for the presence of agent using real-time field analytical methods. Soils with agent are hauled to the incinerator located in the northeast corner of Section 2 in South Plants and treated by rotary kiln incineration (Alternative A4). The operating temperature of the incinerator is 760°C. Soils with a moisture content of 20 percent are processed at a rate of 470 BCY/day and have a residence time of 66 minutes. Section 4.6.26 describes off-gas treatment for the incinerator. The small volume of particulates from the agent incineration (1 percent of

solids feed as particulates from quench blowdown) is landfilled. Soils treated by incineration are backfilled at the sites.

A daily soil cover or plastic liner is placed over the excavated areas to minimize volatile emissions and odors from the excavation. This alternative also includes dewatering of the excavation using groundwater extraction wells. Dewatering is initiated 2 years prior to excavation and continues during the 2-year excavation period. Water removed from the area at 5 gallons per minute (gpm) is pumped to the CERCLA Wastewater Treatment Plant.

After excavation, the soils with human health and biota exceedances are transported and disposed in the on-post hazardous waste landfill. Coinciding with the completion of the incinerator is the construction of the first landfill cell. Construction of the support facilities is to commence during year 2 and requires 1 year for completion. The landfill has a capacity for multiple cells as discussed in Section 4.6. The landfill cover is revegetated after installation and fencing is installed to exclude biota and to prevent damage to the system. Since 830,000 BCY of untreated soil and 43,000 BCY of debris are contained in the landfill, the landfill cover requires long-term monitoring and maintenance. Long-term maintenance activities include collecting and treating leachate and monitoring potential leachate migration from the landfill.

The excavations at the sites are backfilled with soils from the on-post borrow area. Topsoil is placed on the backfilled area and the entire area is revegetated with native grasses, thus improving the habitat at the site. The borrow area is also regraded and revegetated to restore habitat.

Table 10.2-3 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs since the contaminated soils are excavated and landfilled or incinerated, which interrupts exposure pathways and reduces the migration of contaminants to groundwater. The habitat is improved at the site and restored at the borrow area. The disposal of the 830,000 BCY of soils with human health and biota exceedances and the 43,000

BCY of debris requires up to 4 years, based on a 1-year construction period for the first landfill cell and support facilities and a 2-year construction period for the incinerator. The total estimated present worth cost of this alternative, including the human health, biota, agent, and UXO portions, is $62,000,000. Table B4.1-3 details the costing for this alternative.

10.2.4 Alternative 6/B5/A2/U2: Caps/Covers

Alternative 6: Caps/Covers (Clay/Soil Cap), combined with Alternative B5: Caps/Covers (Clay/Soil Cap), Alternative A2: Caps/Covers (Clay/Soil Cap), and Alternative U2: Caps/Covers (Clay/Soil Cap), addresses the containment of 560,000 SY of human health and biota exceedance area. This capped area also includes agent and potential UXO presence areas. Before any cover materials are installed, a surface swep is conducted with a metal detector to ensure that UXO are not present in near surface soils, the subgrade is compacted and grading fill is placed to control surface-water runoff. Up to 700,000 BCY of borrow material are required to develop a concave subgrade within the allowable design grades. In general, grading fill is placed to develop a convex surface, or crown, with grades between 1.5 and 3.0 percent prior to the installation of the cap. However, 1,200,000 to 1,800,000 BCY of soils (depending on the final grade) would be required to develop a crown for Basin A. Alternative 6f: Thermal Desorption of Principal Threat Volume; Caps/Covers (Section 10.2.6) considers the consolidation of contaminated soils to develop the crown surface, but a concave surface with grades between 1.5 and 3.0 percent are to be developed for this alternative to reduce the amount of borrow material required as grade fill.

The human health and biota areas are covered by a 2-ft layer of low-permeability soil, a 1-ft biota barrier of cobbles, and a 4-ft layer of a soil/vegetation layer that includes 6 inches of topsoil. The capped area is then revegetated to restore the habitat. The fill materials for the cap are excavated from on-post borrow areas, and topsoil is obtained off post. The capping operations require 2 years to complete. Maintenance activities (mowing and replacing eroded soils) ensure the continued integrity of the soil cap.

Table 10.2-4 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs through containment. The potential for migration of contaminants to groundwater is greatly reduced, although reductions in mobility may be reversible if the cap degrades or leaks. Habitat is improved at the site after remediation, but remains restricted for burrowing animals. Long-term maintenance is required to ensure the integrity of the cap. The total estimated present worth cost of this alternative is $48,000,000. Table B41.1-6 details the costing for this alternative.

10.2.5 Alternative 6f/B5/A2/U2: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers

Alternative 6f: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume, Caps/Covers (Clay/Soil Cap), along with Alternative B5: Caps/Covers (Clay/Soil Cap), Alternative A2: Caps/Covers (Clay/Soil Cap), and Alternative U2: Caps/Covers (Clay/Soil Cap), involves the treatment of 4,600 BCY of contaminated soils and the containment of 560,000 SY of soils. The 4,600 BCY of soils that exceed the principal threat criteria are excavated for treatment by thermal desorption. During excavation of the principal threat volumes, a daily soil cover or plastic liner is installed to minimize the generation of odors and volatile emissions.

Prior to excavation of the principal threat volume, the area is screened for UXO using geophysics The identified UXO are excavated, packaged, and transported to an off-post facility for demilitarization in accordance with Alternative U4 as described in Section 4.3.5. A surface sweep is conducted with a metal detector to ensure that UXO are not present in near surface soils. The exceedance soils are also screened for agent prior to excavation using real-time field analytical methods. Any agent-contaminated soils identified are treated by incineration (Alternative A4) as described in Section 4.4.4. Potential agent and UXO presence areas not screened as part of the principal threat volume are contained by the low-permeability soil cap.

The excavated principal threat volume is then transported to the thermal desorber for treatment. The thermal desorber requires 2 years to build and an additional year for testing. It processes

saturated soils with a 20-percent moisture content at a rate of approximately 1,300 BCY/day and achieves a soils discharge temperature of 300°C with a soils residence time of 50 minutes. Section 4.6.24 discusses emission controls for off gases from thermal desorption. Particulates from quench blowdown amount to approximately 1 percent of the total solids feed. This particulate volume of 46 BCY is trucked to the on-post landfill for disposal. The treated soils are backfilled into the excavation.

Following the treatment of principal threat volumes, a low-permeability soil cap is installed over the 560,000 SY of soils with human health and biota exceedances, which also includes the potential agent and potential UXO presence areas. The subsurface is regraded and compacted prior to installation of the cap to minimize variations in the subgrade. The cap consists of a 2-ft-thick layer of compacted, low-permeability soil, a 1-ft biota barrier of cobbles, and a 4-ft soil/vegetation layer that includes 6 inches of topsoil. The containment of Basin A requires placement of between 1,200,000 and 1,800,000 BCY of soil as grading fill to bring the area to be capped to the design grade of 1.5 to 3 percent as described in Section 6.2 of the Technology Description Volume. Instead of using borrow material for the fill, contaminated soils from other sites are consolidated within Basin A prior to capping. (The levels of contamination in the consolidated soils is lower than the contaminated soils found in Basin A.) If the consolidation alternatives are not selected for the other medium groups, then borrow materials from the on-post borrow area are used as fill. Topsoil for the final layer of the cap is obtained off post. The remediation of Basin A is completed by revegetation of the cap as well as the borrow area. Although the habitat is improved after remediation, burrowing animals are excluded from the cap to prevent damage to the system. The cover at Basin A provides a physical barrier to protect human and biota receptors from directly contacting soil contaminants, potential agent, and potential UXO. Figure 10.2-1 presents a schematic representation of this alternative, including the installation of grading fill and the low-permeability soil cap.

Table 10.2-5 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs through treatment of principal

threat volumes and the containment of the remaining exceedance areas. The potential for migration of contaminants to groundwater is reduced through the installation of the cap and treatment of principal threat volume. The exposure pathways for hazards from agent and UXO and for human health and biota exceedances are interrupted. Biota disturbance is minimal due to the existing poor-quality habitat. Long-term monitoring includes maintenance of the low-permeability soil cap over Basin A, repair of erosion damage, and maintenance of the landfill containing the particulates from thermal desorption. Five-year site reviews are conducted to assess natural attenuation and potential migration of contaminants. The thermal desorption of the principal threat volume and the installation of the low-permeability soil cap requires 4 years. The estimated present worth cost of this alternative is $39,000,000. Table B4.1-6f details the costing for this alternative.

10.2.6 Alternative 8/B12/A5/U4: Direct Soil Washing; Direct Thermal Desorption; Direct Solidification/Stabilization

Alternative 8: Direct Soil Washing (Solvent Washing); Direct Solidification/Stabilization (Cement-Based Solidification), along with Alternative B12: Direct Soil Washing (Solvent Washing), Alternative A5: Direct Soil Washing (Solvent Washing), and Alternative U4: Detonation (Off-Post Army Facility); Incinerator/Pyrolysis (Off-Post Incineration), treats 830,000 BCY of contaminated soils through solvent washing and 700 BCY of soils containing residual inorganic contamination through solidification.

Prior to the excavation of the 830,000 BCY of contaminated soils, 130,000 SY are screened by geophysical methods to identify any UXO. Confirmed UXO are excavated, packaged, and shipped off post for demilitarization in accordance with Alternative U4. Approximately 43,000 BCY of surficial metallic debris mixed with the soils are removed and disposed in the on-post landfill. Prior to the excavation of exceedance soils, 420,000 SY are also screened using real-time field analytical methods to identify any soils contaminated with agent. Agent-contaminated soils are excavated and treated in accordance with Alternative A5: Soil Washing; Landfill, which consists of solvent/caustic washing and disposal of treated soil in the on-post landfill. Similar

equipment to that used for solvent/caustic washing is used in solvent washing as discussed below. During all excavation operations, daily soil covers or plastic liners are used to minimize the generation of volatile emissions and odors. Excavations are dewatered by extracting groundwater from recovery wells installed around the site. Dewatering is to be initiated 2 years prior to excavation and to continue during the 3-year excavation period. Groundwater is pumped at a rate of 5 gpm to the CERCLA Wastewater Treatment Plant.

The 820,000 BCY of excavated soils are treated at a centralized solvent extraction facility. Nine washing cycles are required to achieve Human Health and Biota PRGs, but the solvent is recycled between washing cycles and treated through distilation (Section 4.6.19). A total of 500,000 gallons of liquid effluent are generated and treated at an off-post commercial facility as part of solvent washing. A total of 30 solvent washing units are required to maintain a throughput of approximately 1200 BCY/day. The treated soils are backfiled and covered with topsoil to promote subsequent revegetation with native grasses.

The 700 BCY of soils with inorganic exceedances are solidified by adding cement as a binder at a 20-percent weight ratio to immobilize the arsenic. These soils are solidified using a portable pug mill located near the thermal desorber that is capable of treating 46 BCY/day. The volume of contaminated soils increases by 20 percent based on bulking from excavation and swelling from solidification, resulting in a total volume of 840 BCY of solidified soils. The solidified soils are placed in the excavated areas and covered with soils treated by thermal desorption. The solidified soils require a soil cover of at least 4 ft to ensure the integrity of the solidified materials and to prevent freeze/thaw degradation of the materials. The site requires regrading due to the volume expansion, and is revegetated with native grasses, thereby improving habitat quality.

Table 10.2-6 presents the detailed analysis of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs since all contaminated soils are treated to remove or destroy the exceedance COCs, agent, and UXO. The habitat is improved at the site following

revegetation. The impacts on groundwater quality are reduced through the treatment of contaminated soils, but more than 500,000 gallons of effluent solutions are generated and are treated off site. The solvent washing of 820,000 BCY and solidification of 700 BCY of soil requires approximately 5 years, including 2 years for construction of facilities. The total estimated present worth cost of this alternative is $230,000,000. Table B4.1-8 details the costing for this alternative.

10.2.7 Alternative 13/B6/A4/U4: Direct Thermal Desorption; Direct Solidification/Stabilization

Alternative 13: Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification), with Alternative B6: Direct Thermal Desorption (Direct Heating), Alternative A4: Incineration/Pyrolysis (Rotary Kiln), and Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration), treats 830,000 BCY of soil with organic COC exceedances by thermal desorption and treats 700 BCY of inorganic COC exceedances by solidification.

Prior to the excavation of the 830,000 BCY of contaminated soils, 130,000 SY are screened by geophysical methods to identify any UXO. Confirmed UXO are excavated, packaged, and shipped off post for demilitarization in accordance with Alternative U4. Approximately 43,000 BCY of surficial metallic debris mixed with soils are removed and disposed in the on-post landfill. Prior to excavation of exceedance soils, 420,000 SY are also screened using real-time field analytical methods to identify any soils contaminated with agent. Agent-contaminated soils are excavated and treated in accordance with Alternative A4: Incineration/ Pyrolysis by rotary kiln incineration at 760°C. The incinerator processes soils at a rate of 470 BCY/day and has a soils residence time of 66 minutes. During all excavation operations, controls of daily soil covers or plastic liners are used to minimize the generation of volatile emissions and odors. Excavations are also dewatered by extracting groundwater from recovery wells installed around the site. Dewatering is initiated 2 years prior to excavation and continues during excavation. Groundwater is pumped at 5 gpm to the CERCLA Wastewater Treatment Plant.

The thermal desorber requires approximately 1 year to build and requires an additional year for testing. For soils from Basin A, which have a moisture content of 20 percent, the thermal desorber can process approximately 1,300 BCY/day, operating at a temperature of 300°C with a soils residence time of 50 minutes. Section 4.5 discusses emission controls for off gases from thermal desorption. Due to the mercury and arsenic content, 8,200 BCY (or 1 percent of the total solids feed) of particulates from the scrubber blowdown are placed in the on-post landfill. The treated soils without human health exceedances for inorganics are backfilled in Basin A. Since thermal desorption destroys the natural organic content of the soils, topsoil needs to be placed on the treated soils in order to allow revegetation of the excavated areas. The arsenic and mercury in most of the treated soils is reduced below the Biota SEC; however, 700 BCY of soils require solidification to address elevated levels of arsenic. Soils with remaining inorganic exceedances are transported to the solidification facility for further treatment.

The 700 BCY of soils with inorganic exceedances are solidified at a rate of 46 BCY/day using a portable pug mill located near the thermal desorber. The contaminated soils are treated by adding cement as a binder at a 20-percent weight ratio in order to immobilize arsenic in the soils. The volume of contaminated soils increases by 20 percent due to bulking from excavation and swelling from solidification. This results in a total volume of 840 BCY of solidified soils for this medium group. The solidified soils are placed in the site excavations and covered with the treated soils from thermal desorption. The cover is revegetated with native grasses, thereby improving habitat quality.

Table 10.2-7 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs since all contaminated soils are treated to remove or destroy the exceedances of COCs, agent, and/or UXO. Residual risk achieves PRGs. The impacts on groundwater quality are reduced through the treatment of contaminated soils, and the habitat is improved at the site following revegetation. The thermal desorption of 830,000 BCY and solidification of 700 BCY of soils require approximately 5 years including the 2 years for

construction and testing of the facilities. The total estimated present worth cost of this alternative is $150,000,000. Table B4.1-13 details the costing for this alternative.

10.2.8 Alternative 17/B11/A4/U4: In Situ Physical/Chemical Treatment; In Situ Thermal Treatment

Alternative 17: In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating), along with alternative B11: In Situ Thermal Treatment (Surface Soil Heating), Alternative A4: Incineration/Pyrolysis (Rotary Kiln), and Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration), consists of treating the highest levels of contamination in the surficial soils using in situ heating and flushing the remaining contaminants from the deeper soils using in situ soil flushing techniques.

Prior to in situ heating, 420,000 SY of Basin A soils that potentially contain agent are screened for agent presence by screening soil borings with real-time field analytical methods. Any soils with agent are excavated and treated on post by rotary kiln incineration in accordance with Alternative A4. The operating temperature of the incinerator is 760°C, and soils with a moisture content of 20 percent are processed at a rate of 470 BCY/day and have a soils residence time of 66 minutes. Section 4.5 discusses the treatment of off gases from incineration. Approximately 1 percent of total solids feed is entrained in the off gas and disposed in the on-post landfill as particulates. In addition, 130,000 SY of soils that may contain UXO are cleared using geophysics. Confirmed UXO are excavated, packaged, and transported to an existing off-post facility for demilitarization in accordance with Alternative U4. The 43,000 BCY of surficial metallic debris and soils associated with UXO removal are excavated and transported to the on-post landfill.

Surficial soils containing exceedances are treated with in situ heating. Surface soil heating raises the temperature of the soils to more than 250°C, mobilizing the organic contaminants located in the near-surface soils. The mobilized contaminants are then collected and treated in the off-gas treatment system (Section 4.5.9). Two soil heating units are used to treat 570,000 SY of Basin

A soils, which contain the highest levels of OCPs. Each surface soil unit treats a block of soil with dimensions of 50 ft by 50 ft and has a treatment rate of approximately 17,000 SY/year. The liquid sidestream from in situ heating, which contains predominantly salts, is transported to the thermal desorption facility for treatment along with the scrubber effluent as part of the air emission control equipment for thermal desorption as described in Section 4.5.24.

In situ soil flushing is initiated following the in situ heating of the surficial soils to remove the lower levels of OCPs, arsenic, and mercury from subsurface soils. These contaminants are mobilized by flushing surfactant solutions through unsaturated soils to the underlying groundwater. Dilute surfactant solutions are applied by ponding the solutions within a bermed area. The flushed contaminants are subsequently collected and treated at the Basin A Neck IRA treatment system after the system is expanded to handle a capacity of approximately 70 gpm. After the treated soils have been allowed to drain for 1 year, the entire area is covered with topsoil obtained off post and is revegetated with native grasses to restore the habitat.

Table 10.2-8 details the evaluation of this alternative against the EPA criteria for the DAA. Soil flushing can theoretically achieve most Human Health and Biota RAOs since most of the remaining COCs can be removed from the soils through the flushing of four soil-pore volumes. However, soil washing treatability studies, as described in Section 12.2 of the Technology Description Volume, which were performed in a reactor vessel and included agitation, indicate that soil flushing would at best reduce the concentrations of OCPs to within the acceptable risk range for human health (10^{-6} to 10^{-4} excess cancer risk), but not achieve PRGs (10^{-6} excess cancer risk), which are the point of departure for treatment goals. The residual OCP levels are also anticipated to be greater than the Biota PRGs. The treatment time frame for this alternative is 27 years. Residual contaminant levels may not be reduced to Human Health RAOs within the 30-year remediation time frame, due to the long period of time required for soil flushing. The treated areas are revegetated to improve habitat, but some biota risk remains due to the failure to achieve Biota PRGs. The total estimated present worth cost of this alternative is $260,000,000. Table B4.1-17 details the costing for this alternative.

10.2.9 Alternative 19/B11a/A4/U4: In Situ Thermal Treatment; In Situ Solidification/Stabilization

Alternative 19: In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification), along with Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating), Alternative A4: Incineration/Pyrolysis (Rotary Kiln), and Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration), treats 830,000 BCY of soils with organic contamination by in situ RF heating and 700 BCY of soils with inorganic contamination by in situ solidification.

Prior to treatment, 420,000 SY of Basin A that potentially contain agent are screened using real-time field analytical methods. Any soils identified with agent are excavated and treated on post by rotary kiln incineration in accordance with Alternative A4. The operating temperature of the incinerator is 760°C. Soils with a moisture content of 20 percent are processed at a rate of 470 BCY/day and have a soils residence time of 66 minutes. Section 4.5 discusses the treatment of off gases from incineration. Approximately 1 percent of the total feed is entrained in the off gas and disposed in the on-post landfill as particulates. In addition, 130,000 SY of soils that may contain UXO are cleared using geophysics to identify any UXO. Confirmed UXO are excavated, packaged, and transported to an existing off-post Army facility for demilitarization in accordance with Alternative U4. The 43,000 BCY of surficial metallic debris mixed with soils are excavated and transported to the on-post landfill to complete the treatment of UXO.

Organic exceedance volumes are treated in situ by RF heating. RF heating elevates the temperature of the soil to more than 250°C, which mobilizes the organic contaminants. The mobilized contaminants are then collected and treated in the off-gas treatment system as described in Section 4.6.29. One RF unit is used for Basin A. The unit treats a block of soil approximately 100 ft long by 48 ft wide and up to 10 ft deep at a treatment rate of approximately 130 BCY/day (assuming 20 percent soil moisture). The treatment rate decreases as the moisture content increases. The liquid sidestream, which contains predominantly salts, is transported to the thermal desorption facility for treatment along with the scrubber effluent from that system.

RF heating only treats the organic contaminants, so soils containing inorganic exceedances are addressed through in situ cement-based solidification. To reduce heating costs, the area is dewatered prior to treatment. Groundwater is to be pumped from recovery wells around the site to the CERCLA Wastewater Treatment Plant.

The human health inorganic exceedance volume of 700 BCY is solidified by a transportable track-mounted boring/mixing unit and a cement batch plant capable of processing 600 BCY of soils per day. Portland cement is mixed with soils at a ratio of 0.2 tons of cement per ton of soil. Upon solidification, the soil swells approximately 20 percent due to the incorporation of the cement. Up to 4 ft of soil is placed over the solidified soil (3,000 SY) and regraded prior to the placement of a 6-inch layer of topsoil over the entire human health and biota exceedance area of 560,000 SY. The soil cover ensures the integrity of the solidified soils and prevents freeze/thaw degradation of the solidified soils. Borrow material is taken from the on-post borrow area and the topsoil is obtained off post. The treated human health and biota areas are revegetated with native grasses.

Table 10.2-9 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. RF heating can theoretically achieve Human Health and Biota RAOs with low residual risk since OCPs and volatile metals can be driven from the soil by this form of in situ thermal treatment. However, the pilot-scale test of the RF technology at RMA, as described in the Technology Description Volume, failed to confirm the temperature distribution and OCP removal required for confident treatment of soils to achieve PRGs: although Human Health PRGs are achieved, Biota PRGs are not, based on the 97-99.9 percent destruction removal efficiency (DRE) of the pilot test. The treated areas are revegetated to improve habitat, but some biota risk remains due to the failure to achieve Biota PRGs. The implementability of in situ RF heating is questionable since there is no commercial source for the equipment and the technique is as yet unproven at full scale. RF heating of 830,000 BCY of contaminated soils is feasible within 20 years. The total estimated present worth cost of this alternative is $260,000,000. Table B4.1-19 details the costing for this alternative.

10.3 SELECTION OF PREFERRED ALTERNATIVE

The Basin A Medium Group contains 830,000 BCY of contaminated soils. The predominant COCs are OCPs, although mercury and arsenic are also present. Manufacturing wastewater effluent, which contained a combination of organic and inorganic contaminants, was historically dumped into Basin A. As such, the contamination patterns are relatively homogeneous compared to the heterogeneous contamination patterns of disposal trenches and sites with isolated spills. Less than 30 percent of the samples in Basin A contained an OCP above the Human Health SEC, but nearly 75 percent of the samples contained OCPs above the Biota SEC (Table 10.1-2). The contaminants in the exceedance volumes in Basin A represent a relatively low risk to human health as the average concentrations of individual OCPs are below or slightly above the Human Health SEC. Nontheless, the average OCP concentrations are substantially higher than the Biota SEC (Table 10.1-1).

Approximately 4,600 BCY of contaminated soils within Basin A are considered to represent a principal threat volume based on elevated levels of OCPs, primarily chlordane. The areas identified as principal threats consist of lower lying areas in the central and southern portions of the basin where liquids may have ponded (Figure 10.2-1). These areas are not contiguous, but they are defined by four samples with higher levels of chlordane than is found in nearby borings (Table 10.1-2). The principal threat volume is contained within the uppermost 2 feet.

A large portion of Basin A potentially contains Army agent and the eastern portion of the basin potentially contains UXO (Figure 10.2-2). Since the liquid wastes disposed in Basin A were treated for agent in the Buried M-1 Pits and the Section 36 Lime Basins prior to disposal, the probability of detecting agent in the Basin A soils is lower than for the chemical sewers and disposal trenches where raw agent was conveyed or disposed. The ongoing Volume Refinement Program will collect samples from areas of Basin A where agent may occur in an attempt to verify its presence or absence. Several UXO were removed from the surface of Basin A prior to the RI program, indicating that subsurface UXO may be present in the eastern portion of the basin near sites in the Complex Disposal Trenches Subgroup.

The Basin A area is considered to be poor-quality habitat due to the vegetation types encountered. As such, disturbance of the basin during remedial actions does not present a significant decrease in available habitat. Although the sites in Basin A have been identified as sources of a contaminated groundwater plume, the Basin A Neck IRA treatment system intercepts contaminated groundwater immediately downgradient of the site.

The presence of high levels of OCPs in some areas and the potential presence of agent and UXO indicate that controls are required for the protection of site workers and the community for remedial actions that involve excavation of the Basin A soil. The excavated areas would be limited and use of a daily cover or a plastic liner is required to limit odor emissions. Furthermore, areas to be excavated are screened for agent through field sampling and cleared for subsurface UXO through geophysics.

In summary, while limited areas of Basin A contain high concentrations of OCPs, most of the basin contains relatively low levels of chemical contaminants, and any contaminants being mobilized from the soils are intercepted by the Basin A Neck IRA. However, Army agent and UXO are potentially present. The short-term risks of potential worker and community exposure related to UXO, Army agent, and the release of vapors, and the long time period needed to complete a treatment alternative (5-27 years) must be balanced against the short time frame required to complete a containment alternative (2 years) and again in the long term, risks of leaving contamination in place.

Alternative 1: No Additional Action does not achieve Human Health or Biota RAOs as untreated soils remain on post and no controls are implemented and so is eliminated from further consideration as the preferred alternative. Although Alternative 1a: Direct Thermal Desorption of Principal Threat Volume; No Additional Action treats the highest levels of contamination, Human Health and Biota RAOs are not achieved for the majority of soils in this medium group and this alternative is also eliminated from further consideration. The remaining seven alternatives achieve RAOs, and meet the two DAA threshold criteria: protection of human health

and the environment and compliance with action-specific and location-specific ARARs, for the DAA. The remaining alternatives all satisfy the DAA threshold criteria, but exhibit differences among the balancing criteria (Tables 10.2-1 through 10.2-8).

Alternative 17: In Situ Physical/Chemical Treatment; In Situ Thermal Treatment and Alternative 19: In Situ Thermal Treatment; In Situ Solidification/Stabilization achieve RAOs, but are not capable of achieving Human Health or Biota PRGs based on the DREs of the in situ technologies. The concentrations of organic contaminants are reduced through these alternatives, and the human health risk achieves the remediation goal of 10^{-6} excess cancer risk for most contaminants and is within the acceptable risk range for the other contaminants. However, residual risk to biota exists as the removal efficiencies are not capable of achieving the Biota PRGs in most portions of the medium group. The in situ thermal treatment processes used in Alternatives 17 and 19 are not yet available for full-scale operation.

Three of the alternatives (Alternative 3: Landfill, Alternative 8: Direct Soil Washing; Direct Solidification/Stabilization, and Alterative 13: Direct Thermal Desorption; Direct Solidification/Stabilization) achieve RAOs through removal of the contaminated soils and subsequent treatment/disposal, but these alternatives involve agent/UXO clearance and treatment, which potentially creates a high risk to workers. In addition, Alternative 8 requires additional treatment of the liquid sidestream. Alternative 8 has the highest cost of these three alternatives ($230,000,000). Alternative 3: Landfill does not treat the contaminated soil prior to containment, but does achieve RAOs. Alternative 6: Caps/Covers achieves RAOs through containment and does not involve excavation.

The cost of Alternative 6f: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers ($39,000,000) is significantly lower than five of the other protective alternatives and creates lower short-term impacts as only 4,600 BCY of soil within the principal threat area are excavated. In addition, this alternative does not involve the excavation of all areas with the potential presence of agent and/or UXO and is therefore more protective of workers than the

other retained alternatives. Alternative 6f is slightly less expensive than Alternative 6 since the cost for consolidating contaminated soils into Basin A to form the grading fill is accounted for in the costs for the subgroups/medium groups that contribute the fill.

The preferred alternative for the Basin A Medium Group is Alternative 6f paired with analogous Caps/Covers alternatives for the biota, agent, and UXO exceedance areas. This alternative is protective of human health and biota since the contaminated material in the principal threat areas is treated prior to containment. This alternative is consistent with the NCP guidance (EPA 1990) on selecting treatment for higher levels of contamination and initiating engineering controls, such as containment with a low-permeability soil cap, for areas with lower levels of contamination. The lower cost of this alternative, combined with the reduction in worker exposure, makes this alternative cost-effective for this medium group. The installation of the low-permeability soil cap and treatment of the principal threat volume significantly reduces the infiltration of water and the migration of contaminants to groundwater and surface water.

In addition to providing a cost-effective remediation option for the Basin A Medium Group, Alternative 6f can be used to decrease the cost of remediation at other sites within RMA. The cost reduction can be achieved by consolidating contaminated material from other sites under the Basin A cap as part of the 1,200,000 to 1,800,000 BCY of soils needed (depending on the final grade) to regrade Basin A to achieve adequate drainage. Using contaminated material from other sites reduces the number of containment locations at RMA, thereby reducing the areas requiring long-term maintenance. Monitoring and maintenance is established as part of this alternative for Basin A, and the consolidation of materials within Basin A eliminates the need for additional monitoring and maintenance of other containment sites across RMA. Although additional contaminant mass is placed in Basin A from the consolidation of contaminated soils, the installation of a low-permeability soil cap significantly reduces the risks for groundwater contamination in Basin A. The debris from the demolition of structures can also be consolidated in Basin A. The structural debris provides a stable subgrade layer for the clay/soil cap.

Table 10.0-1 Characteristics of Basin A Medium Group

Characteristic	Basin A Medium Group
Contaminants of Concern	
Human Health	OCPs, ICPs, As,
Biota	OCPs, As, Hg
Exceedance Areas (SY)	
Total	560,000
Human Health	280,000
Biota	290,000
Potential Agent	420,000
Potential UXO	130,000
Exceedance Volume (BCY)	
Total	830,000
Human Health	330,000
Organic	330,000
Inorganic	700
Principal Threat	4,600
Biota	500,000
Potential Agent	700
Potential UXO	90
Depth of Contamination (ft)	
Human Health	0–0, mostly 0–5
Biota	0–10, mostly 0–8

Table 10.1-1 Summary of Concentrations for the Basin A Medium Group

Contaminants of Concern	Range of Concentrations[2] (ppm)	Average Concentration[2] (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC (ppm)
Human Health Exceedance Volume					
Aldrin	BCRL–240	18	56	560	0.68
Dieldrin	BCRL–360	27	40	400	0.83
Endrin	BCRL–120	6.6	15	15,000	0.029
Isodrin	BCRL–32	1.7	3.4	3,400	not applicable
Chlordane	BCRL–270	23	3.1	260	not applicable
Arsenic	BCRL–630	70	530	5,300	16.5
Chromium	25–73	12	40	10,000	not applicable
p,p,DDT[1]	BCRL–29	0.95	26	1,300	1.4
p,p,DDE[1]	BCRL–6.9	0.52	130	1,300	0.20
Mercury[1]	BCRL–180	9.7	470	470,000	0.99
Biota Exceedance Volume					
Aldrin	BCRL–18	0.5	56	560	0.68
Dieldrin	BCRL–22	1.2	40	400	0.83
Endrin	BCRL–6.1	0.3	15	15,000	0.029
Arsenic	BCRL–370	30	530	5,300	16.5
Mercury	BCRL–56	1.2	470	470,000	0.99
p,p,DDT	BCRL–0.29	0.01	26	1,300	1.4
p,p,DDE	BCRL–0.37	0.005	130	1,300	0.2

1 Present above the Biota SEC only, but was detected in the human health exceedance volume.
2 Based on modeled concentrations within exceedance volume.

Table 10.1-2 Frequency of Detections for Basin A Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	349	294	84.2%	19	5.4%	30	8.6%	6	1.7%	0	0.0%
Benzene	91	87	95.6%	4	4.4%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	91	91	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	350	301	86.0%	22	6.3%	--	--	24	6.9%	3	0.9%
Chloroacetic Acid	32	32	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlorobenzene	91	87	95.6%	4	4.4%	--	--	0	0.0%	0	0.0%
Chloroform	91	91	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	349	314	90.0%	21	6.0%	14	4.0%	0	0.0%	0	0.0%
p,p,DDT	349	324	92.8%	20	5.7%	4	1.1%	1	0.3%	0	0.0%
Dibromochloropropane	175	173	98.9%	2	1.1%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	91	91	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	37	37	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	186	180	96.8%	6	3.2%	--	--	0	0.0%	0	0.0%
Dieldrin	349	198	56.7%	80	22.9%	58	16.6%	12	3.4%	1	0.3%
Endrin	349	262	75.1%	35	10.0%	42	12.0%	10	2.9%	0	0.0%
Hexachlorocyclopentadiene	349	335	96.0%	13	3.7%	--	--	0	0.0%	0	0.0%
Isodrin	349	319	91.4%	22	6.3%	--	--	8	2.3%	0	0.0%
Methylene Chloride	76	59	77.6%	17	22.4%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	91	82	90.1%	9	9.9%	--	--	0	0.0%	0	0.0%
Toluene	91	87	95.6%	4	4.4%	--	--	0	0.0%	0	0.0%
Trichloroethylene	91	88	96.7%	3	3.3%	--	--	0	0.0%	0	0.0%
Arsenic	339	150	44.2%	93	27.4%	91	26.8%	5	1.5%	0	0.0%
Cadmium	217	154	71.0%	63	29.0%	--	--	0	0.0%	0	0.0%
Chromium	217	22	10.1%	193	88.9%	--	--	2	0.9%	0	0.0%
Lead	217	163	75.1%	54	24.9%	--	--	0	0.0%	0	0.0%
Mercury	355	190	53.5%	125	35.2%	40	11.3%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.

Table 10.2-1 Evaluation of Alternative 1: No Additional Action (Provisions of FFA); Alternative B1: No Additional Action (Provisions of FFA); Alternative A1: No Additional Action (Provisions of FFA); Alternative U1: No Additional Action for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Does not achieve Human Health or Biota RAOs as untreated soils remain if controls are not implemented. Long-term reduction in toxicity of contaminants through natural attenuation; groundwater impacts not reduced.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs as long-term monitoring and site reviews achieved.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin A Medium Group not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) High residual risk. High concentrations of OCPs, chromium, mercury, and arsenic above Human Health SEC and OCPs, arsenic, and mercury above Biota SEC remain in soil and may impact human health and biota.
	b) No controls implemented. Site reviews and groundwater monitoring required.
b) Adequacy and reliability of controls	c) Habitat quality not improved. Existing poor-quality habitat not impacted by remedial alternative.
c) Habitat impacts	
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction in contaminant volume or mobility except by natural attenuation; 830,000 BCY of untreated soils remain; no reduction in hazards for agent or UXO presence.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or vapor emissions.
c) Environmental impacts of remedial actions	c) No environmental impacts. Existing poor-quality habitat not impacted by remedial alternative; migration of contaminants to groundwater not reduced.
d) Time until RAOs are achieved	d) >30 years. Natural attenuation only process for contaminant reduction; soils with potential agent and UXO remain on site.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Monitoring services readily available.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $4,000,000
d) Total	d) $4,000,000

Table 10.2-2 Evaluation of Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA); Alternative B1: No Additional Action (Provisions of FFA); Alternative A1: No Additional Action (Provisions of FFA); Alternative U1: No Additional Action (Provisions of FFA) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Does not achieve Human Health or Biota RAOs as untreated soils remain if controls are not implemented although principal threat volume treated. Long-term reduction in toxicity of contaminants through natural attenuation for balance of areas; principal threat volume treated to organic detection levels and inorganics reduced below Human Health and Biota SEC; blowdown solids placed in on-post landfill; groundwater impacts not reduced except for principal threat volume.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-10, and A-17)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin A Medium Group, thermal desorption facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Moderate residual risk. 4,600 BCY thermally desorbed and returned site as backfill; soils with chlordane above Human Health SEC and OCPs, arsenic, and mercury above Biota SEC remain in soil; approximately 1% of solids feed recovered from off-gas treatment equipment placed in on-post landfill; potential presence of agent and UXO remain.
b) Adequacy and reliability of controls	b) No controls implemented for balance of site, but adequate controls for particulates; site reviews and groundwater monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality not improved for balance of site; habitat restored for principal threat area through revegetation; existing poor-quality habitat for balance of site not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 4,600 BCY of principal threat volume thermally desorbed to destroy OCPs and remove mercury; no reduction in contaminant volume or mobility except by natural attenuation for balance of site: 830,000 BCY of untreated soils remain; no reduction in hazards for agent or UXO in remaining soils.
b) Degree and quantity of TMV reduction	b) Organics reduced to below detectable levels (>99.99% destruction removal efficiency): TMV of organics eliminated; mercury removed below Biota SEC; arsenic and ICP metals reduced below Human Health and Biota SEC following solids blending and limited volatilization during thermal desorption (20 to 30%); scrubber blowdown solids from off-gas treatment equipment with mercury, arsenic, ICP metals, and salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible.
d) Type and quantity of treatment residuals	d) 46 BCY of blowdown solids with arsenic, mercury, ICP metals, and salts landfilled.

Table 10.2-2 Evaluation of Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA); Alternative B1: No Additional Action (Provisions of FFA); Alternative A1: No Additional Action (Provisions of FFA); Alternative U1: No Additional Action (Provisions of FFA) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent/UXO screening, excavation, transportation, and treatment of principal threat volume.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; odor and vapor emissions controlled by limited excavation and daily soil covers or plastic liners; vapor emissions associated with thermal desorber controlled by air emissions control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impacts to biota due to existing poor-quality habitat; migration of contaminants to groundwater not reduced except for principal threat area.
d) Time until RAOs are achieved	d) > 30 years. Excavation and treatment of 4,600 BCY feasible within 1 year after 2 years for construction of thermal desorption facility; soil with potential agent and UXO remain on site; natural attenuation of untreated soils ongoing.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; landfill cell monitored; additional remedial actions easily undertaken for soils left in place;
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of thermal treatment unit and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers; equipment, specialists, and materials readily available for landfill construction; thermal desorbers and landfills well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $120,000
b) Operating	b) $960,000
c) Long-term	c) $3,500,000
d) Total	d) $4,600,000

Table 10.2-3 Evaluation of Alternative 3: Landfill (On-Post Landfill); Alternative B3: Landfill (On-Post Landfill); Alternative A4: Incineration/Pyrolysis (Rotary Kiln); Alternative U4: Detonation (Off-Post Army Facility) Incineration/Pyrolysis (Off-Post Incineration) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; contaminated soils contained in on-post landfill, preventing human and biota exposure; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-2, A-9, A-11, A-16, and A-17	a) Complies with action-specific ARARs including state regulations on landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2	b) Complies with location-specific ARARs as Basin A Medium Group, incinerator, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding agent and UXO demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 830,000 BCY of untreated soil contained in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Landfill cell monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls of landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat at site but eliminates poor-quality habitat at landfill.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Exposure pathways interrupted and mobility of contaminants reduced through containment of 830,000 BCY in on-post landfill; soils with agent and UXO identified and treated.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if landfill fails.
d) Type and quantity of treatment residuals	d) Groundwater removed by dewatering system at 5 gpm pumped to CERCLA Wastewater Treatment Plant.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent/UXO clearance, dewatering, excavation, and transportation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; odors and vapor emissions controlled limited excavation and daily soil covers or plastic liners.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 4 years. Excavation of 830,000 BCY feasible within 2 years after 2 years for construction of landfill and incinerator for agent treatment.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cells monitored; additional remedial actions require removal of landfill cover; dewatering required.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily implemented. Equipment, specialists, and materials (including clay) readily available for construction of landfill; landfills well demonstrated at full scale.

7. Present worth costs

a) Capital	a) $17,000,000
b) Operating	b) $41,000,000
c) Long-term	c) $ 3,100,000
d) Total	d) $62,000,000

Table 10.2-4 Evaluation of Alternative 6: Caps/Covers (Clay/Soil Cap); Alternative B5: Caps/Covers (Clay/Soil Cap); Alternative A2: Caps/Covers (Clay/Soil Cap); Alternative U2: Caps/Covers (Clay/Soil Cap) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; contaminated soils above Human Health and Biota SECs covered by clay/soil cap, biota barrier, and vegetative layer, preventing exposure; groundwater impacts reduced.
2. Complies with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-5)	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin A Medium Group not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA but does not achieve Army regulations (AMC-R 385-131) regarding agent or UXO demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 830,000 BCY of untreated soils contained through installation of 560,000 SY of clay/soil cap with biota barrier.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for untreated soils; erosion control and vegetative cover maintenance required; high confidence in engineering controls of clay/soil cap.
c) Habitat improved	c) Habitat quality improved. Revegetation of cap with native grasses improves habitat quality. Restrictions to burrowing animals help preserve integrity of cap and to prevent exposure.
4. Reduction in TMV through treatment	
a) Treatment process used and materials treated	a) No materials treated. Exposure pathways interrupted and mobility of contaminants reduced through installation of 560,000 SY of clay/soil cap; soils with agent contained with clay/soil cap.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if cap/cover degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent/UXO clearance and installation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dust controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to moderate-existing habitat.
d) Time until RAOs are achieved	d) 3 years. Installation of 560,000 SY clay/soil cap feasible within 3 years; natural attenuation of untreated soils ongoing.

Table 10.2-4 Evaluation of Alternative 6: Caps/Covers (Clay/Soil Cap); Alternative B5: Caps/Covers (Clay/Soil Cap); Alternative A2: Caps/Covers (Clay/Soil Cap); Alternative U2: Caps/Covers (Clay/Soil Cap) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required timeframe and reliably maintained thereafter; additional remedial actions easily undertaken for soils left in place, although cap adds to overall site volume.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of cap/cover design and construction regulations.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment and specialists readily available for cap/cover construction; clay/soil caps well demonstrated at full-scale.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $34,000,000
c) Long-term	c) $14,000,000
d) Total	d) $48,000,000

Table 10.2-5 Evaluation of Alternative 6f: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap); Alternative B5: Caps/Covers (Clay/Soil Cap); Alternative A2: Caps/Covers (Clay/Soil Cap); Alternative U2: Caps/Covers (Clay/Soil Cap) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment of principal threat volume and containment of balance of areas; principal threat volume treated to organic detection level and inorganics reduced below Human Health and Biota SEC; contaminated soils for balance of areas covered by clay/soil cap, preventing human and biota exposure; blowdown solids placed in on-post landfill; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-5, A-8, A-10, A-17)	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material; state regulations on air emissions sources and landfill siting, design, and operation achieved; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2	b) Complies with location-specific ARARs as Basin A Medium Group, thermal desorption facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA, and Army regulations (AMC-R 385-131) regarding agent and UXO demilitarization for principal threat areas.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 4,600 BCY thermally desorbed and returned to site as backfill; 830,000 BCY of untreated soils contained through installation of 560,000 SY clay/soil cap; approximately 1% of solids feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for untreated soils; erosion control and vegetative cover maintenance required; no difficulties associated with landfill maintenance; high confidence in engineering controls of clay/soil cap and landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat; restrictions to burrowing animals help preserve integrity of cap and prevent exposure.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 4,600 BCY of principal threat volume thermally desorbed to destroy organics and remove mercury exposure pathways interrupted and mobility of contaminants reduced through installation of 560,000-SY clay/soil cap; soils with agent/UXO contained with clay/soil cap.
b) Degree and quantity of TMV reduction	b) Organics reduced below detection level (>99.99% destruction removal efficiency); TMV of organics eliminated; mercury removed below Biota SEC; arsenic and ICP metals reduced below Human Health and Biota SEC following solids blending as a pre-treatment and limited volatilization during thermal desorption (20 to 30%); scrubber blowdown solids from off-gas treatment equipment with mercury, arsenic, ICP metals, and salts placed in landfill.
c) Irreversibility of TMV reduction	c) TMV by thermal desorption irreversible; mobility reduction reversible if cap degrades or leaks.
d) Type and quantity of treatment residuals	d) 46 BCY of blowdown solids with arsenic, mercury, chromium, and salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during cap installation, excavation, transportation, and treatment of principal threat volume.
b) Protection of community during remedial action	b) Protective of community. Water spraying adequate to minimize fugitive dusts controlled by water spraying; odor and vapor emissions controlled limited excavation and daily soil covers or plastic liners; vapor emissions associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to of existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 4 years. Excavation and treatment of 4,600 BCY feasible within 1 year after 2 years for construction of thermal desorption facility; installation of 560,000-SY clay/soil cap feasible within 1 year; natural attenuation of untreated soils ongoing.

Table 10.2-5 Evaluation of Alternative 6f: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap); Alternative B5: Caps/Covers (Clay/Soil Cap); Alternative A2: Caps/Covers (Clay/Soil Cap); Alternative U2: Caps/Covers (Clay/Soil Cap) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; additional remedial actions easily undertaken for soils left in place, although cap adds to overall site volume;
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of thermal treatment unit and landfill siting, design, and operating regulations and cap/cover design and construction regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorber; equipment, specialists, and materials readily available for clay/soil cap and landfill construction; thermal desorbers and landfills well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) \$ 120,000
b) Operating	b) \$26,000,000
c) Long-term	c) \$13,000,000
d) Total	d) \$39,000,000

Table 10.2-6 Evaluation of Alternative 8: Direct Soil Washing (Solvent Washing); Direct Solidification/Stabalization (Cement-Based Solidification) Alternative B12: Direct Soil Washing (Solvent Washing); Alternative A5: Direct Soil Washing (Solvent Washing); Alternative U4: Detonation (Off-Post Incineration) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment/immobilization; contaminated soils treated to organic detection levels; exposure pathways interrupted through solidfication of contaminated soils; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-10 and A-23)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin A Medium Group, treatment facilities, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding agent and UXO demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 820,000 BCY treated by solvent washing and returned to site as backfill; 700 BCY treated by caustic washing and landfilled; 700 BCY solidified and returned to site as backfill.
b) Adequacy and reliability of controls	b) Adequate controls. Monitoring of solidified soils required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 820,000 BCY solvent washed to degrade OCPs; exposure pathways interrupted and mobility of contaminants reduced by solidification of soils with inorganic comtaminants; soils with agent and UXO identified and treated.
b) Degree and quantity of TMV reduction	b) Organics reduced to below PRGs (>99.9% destruction removal efficiency). TMV of organics eliminated.
c) Irreversibility of TMV reduction	c) TMV reduction by solvent washing irreversible.
d) Type and quantity of treatment residuals	d) 500,000 gallons of liquid effluent from solvent washing drummed and transported off-post for treatment; 700 BCY of solidified soils backfilled and monitored; 700 BCY of treated soils landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protect- workers during agent/UXO clearance, dewatering, excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation; vapor emissions associated with solvent washer controlled by air emissions control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impact. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 4 years. Cxcavation and treatment of 820,000 BCY feasible within 3 years after 1 year for construction of a landfill; caustic washing of 700 BCY feasible within 2 yarrs; solidfication of 700 BCY feasible within 1 year.

Table 10.2-6 Evaluation of Alternative 8: Direct Soil Washing (Solvent Washing); Direct Solidification/Stabalization (Cement-Based Solidification) Alternative B12: Direct Soil Washing (Solvent Washing); Alternative A5: Direct Soil Washing (Solvent Washing); Alternative U4: Detonation (Off-Post Incineration) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; landfill cell monitored; solidfied soils monitored to insure integrity; dewatering required.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment units and landfill siting design, and operating regulations.
c) Availability of services and materials	c) Available. Limited vendor sources available for solvent washing until; equipment, specialists, and materials readily available for construction of landfill; landfills well demonstrated at full scale; solvent washing semonstrated at full scale but for units with limited throughout.
7. Present worth costs	
a) Capital	a) $43,000,000
b) Operating	b) $180,000,000
c) Long-term	c) $350,000
d) Total	d) $230,000,000

Table 10.2-7 Evaluation of Alternative 13: Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification); Alternative B6: Direct Thermal Desorption (Direct Heating); Alternative A4: Incineration/Pyrolysis (Rotary Kiln); Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment/immobilization; contaminated soils treated to organic detection levels; exposure pathways interrupted through solidification of contaminated soils; blowdown solids placed in on-post landfill; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-9, A-10, A-11, A-16, A-17, and A-18	a) Complies with action-specific ARARs including state regulations on air emissions and landfill siting, design, and operation; solidified soils monitored; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix a, Table A-2	b) Complies with location-specific ARARs as Basin A Medium Group, treatment facilities, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance.	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding agent and UXO demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 830,000 BCY thermally desorbed and returned to site as backfill; 700 BCY solidified and returned to site as backfill; approximately 1% of solids feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Monitoring of solidified soils required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 830,000 BCY thermally desorbed to degrade OCPs and remove mercury; exposure pathways interrupted and mobility of contaminants reduced by solidification of 700 BCY of soils with inorganic contaminants; soils with agent and UXO identified and treated.
b) Degree and quantity of TMV reduction	b) Organics reduced to below detection levels (>99.99% destruction removal efficiency): TMV of organics eliminated; mercury removed below Biota SEC; arsenic reduced below Human Health and Biota SEC following solids blending and limited volatilization during thermal desorption (20 to 30%); arsenic and ICP metals above Human Health SEC immobilized through cement-based solidification; scrubber blowdown solids from off-gas treatment equipment with mercury, arsenic, ICP metals, and salts contained in landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible; mobility reduction by solidification irreversible if integrity of solidified soils maintained.
d) Type and quantity of treatment residuals	d) Approximately 8,200 BCY of blowdown solids with mercury, arsenic, ICP metals, and salts landfilled; 970 BCY of solidified soils backfilled and monitored; groundwater removed by dewatering system pumped at 5 gpm to CERCLA Wastewater Treatment Plant.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent/UXO clearance, dewatering, excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; odor and vapor emissions controlled by limited excavation and daily soil covers or plastic liners; vapor emissions associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impacts to biota due to existing poor-quality habitat; migration of contaminants to groundwater.
d) Time until RAOs are achieved	d) 5 years. Excavation and treatment of 830,000 BCY feasible within 3 years after 2 years for construction of thermal desorption facility, incinerator for agent treatment, and landfill; solidification of 700 BCY feasible within 1 year.

Table 10.2-7 Evaluation of Alternative 13: Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification); Alternative B6: Direct Thermal Desorption (Direct Heating); Alternative A4: Incineration/Pyrolysis (Rotary Kiln); Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter, landfill cell monitored; solidified soils monitored to insure integrity; dewatering required.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of thermal treatment unit and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers and solidification unit; equipment, specialists, and materials readily available for construction of landfill; thermal desorbers, landfills, and solidification well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $ 23,000,000
b) Operating	b) $130,000,000
c) Long-term	c) $ 370,000
d) Total	d) $150,000,000

Table 10.2-8 Evaluation of Alternative 17: In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating); Alternative B11: In Situ Thermal Treatment (Surface Soil Heating); Alternative A4: Incineration/Pyrolysis (Rotary Kiln); Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment, but concentrations not reduced to achieve PRGs for point of departure; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs)see Technology Description Document, Appendix A, Tables A-1, A-8, A-9, A-11, A-13, A-16, A-17, and A-22)	a) Complies with action-specific ARARs including state regulations on air emissions sources; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin A Medium Group and incinerator not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding agent and UXO demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk within acceptable range. 570,000 SY thermally treated in surficial soils but Biota PRGs not achieved; 330,000 BCY treated by soil flushing in place.
b) Adequacy and reliability of controls	b) Controls not required. Monitoring of treated soil not required.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, but some biota risk remains as PRGs not achieved.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 570,000 SY treated by in situ surficial soil heating to remove volatiles; 330,000 BCY treated by in situ soil flushing to reduce TMV of contaminants; soils with agent/UXO identified and treated.
b) Degree and quantity of TMV reduction	b) Reductions from surface soil heating (>99% destruction removal efficiency) unable to achieve biota PRGs and soil flushing may not achieve Human Health or Biota PRGs.
c) Irreversibility of TMV reduction	c) TMV reduction by in situ treatment irreversible.
d) Type and quantity of treatment residuals	d) Liquid sidestream from soil flushing treated as part of Basin A Neck IRA; liquid sidestream from air emission control equipment treated at thermal desorption facility with scrubber effluent.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent/UXO clearance and in situ treatment.
b) Protection of community during remedial action	b) Protective of community. Dust emissions controlled by water spraying; vapor emissions associated with in situ heating controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to of existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 27 years. Soil flushing of 330,000 BCY feasible within 10 years after 17 years for in situ soil heating.
6. Implementability	
a) Technical feasibility	a) Potentially technically feasible. Pilot-scale testing of surface soils heating on soils with similar contaminants was sucessful but unproven at full scale; treatment of liquid sidestream required; additional remedial actions easily undertaken for treated soils that do not achieve PRGs.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of applicable treatment system operating regulations.
c) Availability of services and materials	c) Limited availability. No vendor available for full-scale operation; no full-scale demonstration of in situ treatment equipment.

Table 10.2-8 Evaluation of Alternative 17: In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating); Alternative B11: In Situ Thermal Treatment (Surface Soil Heating); Alternative A4: Incineration/Pyrolysis (Rotary Kiln); Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration) for the Basin A Medium Group

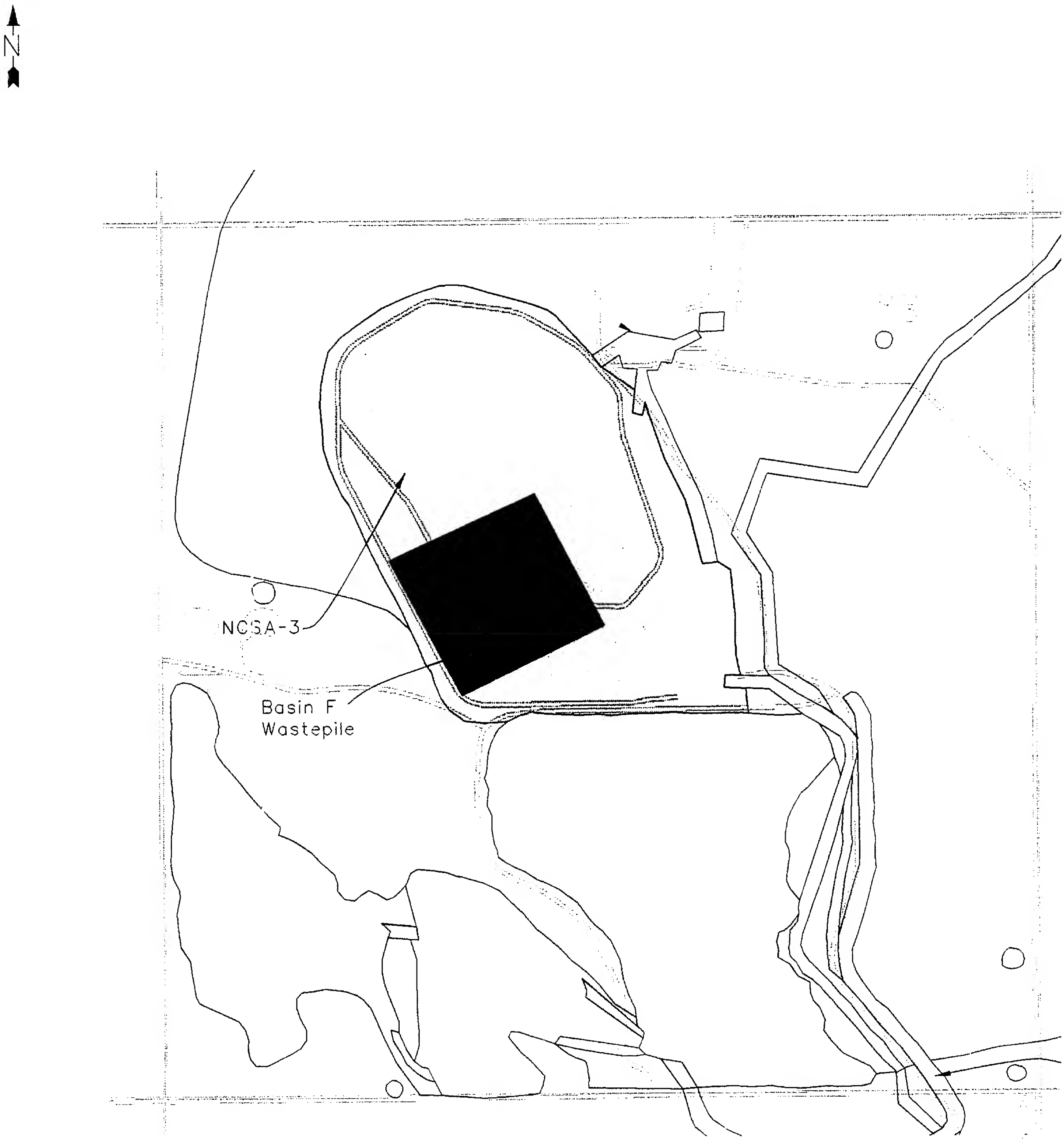
CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $12,000,000
b) Operating	b) $250,000,000
c) Long-term	c) $160,000
d) Total	d) $260,000,000

Table 10.2-9 Evaluation of Alternative 19: In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification); Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating); Alternative A4: Incineration/Pyrolysis (Rotary Kiln); Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration) for the Basin A
' Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment and achieves Human Health PRGs, but concentrations not reduced to achieve Biota PRGs for point of departure; exposure pathways interrupted through solidification of contaminated soils; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-9, A-11, A-13, A-16, A-17, and A-19)	a) Complies with action-specific ARARs including state regulations on air emissions sources; monitoring of solidified soils; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2	b) Complies with location-specific ARARs as Basin A Medium Group not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA and Army regulations (AMC-R 385-131) regarding agent and UXO demilitarization.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk within acceptable range. 820,000 BCY thermally treated in place but Biota PRGs not achieved; reduction in OCP levels are within acceptable range for human health (10^{-4} to 10^{-6} excess cancer risk); arsenic above Biota PRGs remains in soil; 700 BCY with arsenic and ICP metals solidified in place.
b) Adequacy and reliability of controls	b) Controls not required. Monitoring of treated soil not required.
c) Habitat improved	c) Habitat quality improved, but some biota risk remains as Biota PRGs not achieved.
4. Reduction in TMV through treatment	
a) Treatment process used and materials treated	a) 820,000 BCY thermally treated to degrade OCPs and remove mercury; human exposure pathways interrupted and mobility of contaminants reduced by solidification of 700 BCY of soils with inorganic contaminants; soils with agent/UXO identified and treated.
b) Degree and quantity of TMV reduction	b) Reductions from RF heating (>97-99.9% destruction removal efficiency) achieve Human Health PRGs but unable to achieve Biota PRGs. TMV of OCPs reduced during RF heating but concentrations after treatment not able to achieve PRGs; OCP levels in treated soils within acceptable range for human health (10^{-4} to 10^{-6} excess cancer risk); mercury and arsenic condensed in blowdown liquid; mercury removed below Biota SEC; arsenic and ICP metals above Human Health SEC immobilized through cement-based solidification.
c) Irreversibility of TMV reduction	c) TMV reduction by in situ RF heating irreversible; TMV reduction irreversible if integrity of solidified materials maintained.
d) Type and quantity of treatment residuals	d) Liquid blowdown sidestream with elevated salts, arsenic, and mercury concentrations treated at thermal desorption facility with scrubber effluent; 700 BCY of solidified soils monitored; groundwater removed by dewatering system pumped at 5 gpm to CERCLA Wastewater Treatment Plant to reduce RF heating costs.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during agent/UXO clearance dewatering and in situ thermal treatment.
b) Protection of community during remedial action	b) Protective of community. No fugitive dust or odor emissions; vapor emissions associated with RF heating unit controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impact. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 20 years. RF heating of 820,000 BCY feasible within 20 years; solidification of 700 BCY feasible within 1 year after 2 years for construction incinerator for agent treatment.

Table 10.2-9 Evaluation of Alternative 19: In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification); Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating); Alternative A4: Incineration/Pyrolysis (Rotary Kiln); Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration) for the Basin A Medium Group

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Potentially technically feasible. Pilot-scale testing of RF heating conducted on soil with similar contaminants but unproven at full scale; additional remedial actions easily undertaken for treated soils that do not achieve PRGs; solidified soils monitored to ensure integrity; dewatering required.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment system and operating regulations.
c) Availability of services and materials	c) Limited availability. Equipment custom designed for each application and not available; specialists only available through process licensor IITRI; no full-scale demonstration of RF equipment; equipment, specialist, and materials available from several vendors for solidification; solidification well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $14,000,000
b) Operating	b) $240,000,000
c) Long-term	c) $220,000
d) Total	d) $260,000,000



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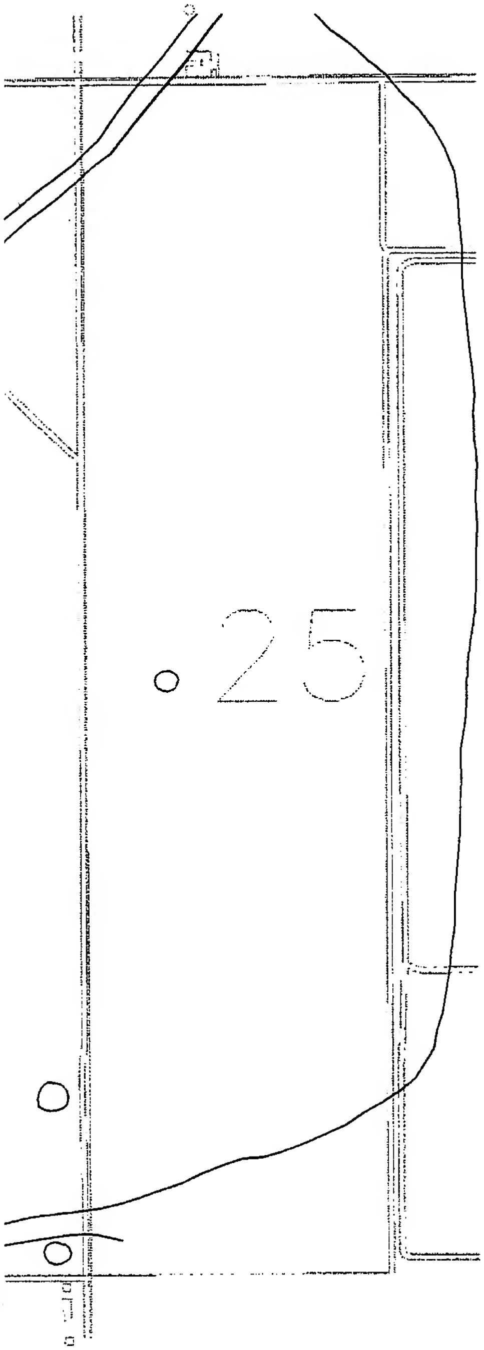
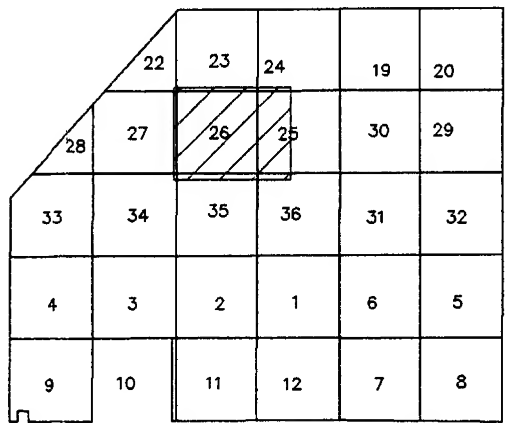


ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Basin F Wastepile Medium Group
SITE: Basin F Wastepile

Former Basin F Subgroup
SITE: NCSA-3, Former Basin F

Site Boundary

Buildings and Roads

26 Section Number

400 0 400 800 FEET

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 11.0-1

Site Location
Basin F Wastepile Medium Group

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated

11.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE BASIN F WASTEPILE MEDIUM GROUP

The Basin F Wastepile Medium Group is composed of one site, a wastepile of sludge and soil removed from Basin F during the Basin F IRA (Figure 11.0-1)(EBASCO 1992a/RIC 92017R01). The Basin F IRA consisted of removing Basin F sludges, excavating all Basin F soils to a depth of 6 inches below the original asphalt liner and excavating selected hotspots to a maximum depth of 6 ft, stabilizing sludges by drying and mixing them with contaminated soil before placement in the lined wastepile, and grading, capping, and revegetating the excavated area.

The sediments and soils in the Basin F Wastepile Medium Group are contaminated with high levels of organic compounds that exceed the principal threat criteria (10^{-3} excess cancer risk, HI of 1,000). This material also contains elevated levels of salts due to the high chloride content in wastewater stored in the former Basin F. Since the entire wastepile is considered a principal threat, areas with biota exceedances only do not exist. This medium group is not considered a source of groundwater or surface-water contamination since the wastepile is contained by a liner and a cap. Table 11.0-1 presents the characteristics of this medium group, and Appendix A details the determination of exceedance areas and volumes.

In the DSA, alternatives were developed and screened based on the general characteristics of the medium group. In the DAA, the characteristics of the Basin F Wastepile Medium Group—including contaminant types, contaminant concentrations, and site configuration—were reviewed to evaluate whether modifications to the retained alternatives for the medium group would be appropriate, but no such modifications were warranted.

The following sections present the characteristics of the medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990), and the selection of a preferred alternative based on a comparative analysis of the alternatives. The preferred alternative is as follows:

- Alternative 6e—Installation of a composite RCRA cap over the Basin F Wastepile as a final cover.

11.1 MEDIUM GROUP CHARACTERISTICS

The Basin F Wastepile Medium Group is composed solely of the wastepile itself (Figure 11.0-1). This site contains contaminated sludge from above the original Basin F asphalt liner and contaminated soils from below the liner. The 33-ft-high wastepile covers an area of 75,000 SY and contains 580,000 BCY of materials. The wastepile liner system consists of two layers of geomembrane liner (primary and secondary layers), two layers of geonet, and one layer of geotextile. One layer of geonet is sandwiched between the primary and secondary liners, which are placed on a compacted soil foundation. The geonet acts as the transmissive component of the leak detection system, allowing leachate to penetrate the primary (upper) geomembrane and flow to leakage collection sumps (secondary sumps) for collection and removal. The other layer of geonet overlies the primary geomembrane and allows leachate retained by the primary geomembrane to flow to leachate collection sumps (primary sumps) for collection and removal. The geotextile overlies the leachate collection geonet and serves as a filter fabric to prevent overlying soil from clogging the pores of the geonet, thereby impeding leachate flow to the primary sump.

The existing wastepile cover system consists of one geomembrane layer, two geonet layers, two geotextile layers, and four soil layers. The bottom layer of the system, a 1-ft soil cover placed directly over the stabilized sludge and soil, provides a foundation for the remainder of the cover system. The next component of the cover system is the gas transmission system, which prevents the buildup of excessive gas pressure within the wastepile that could damage the cover or liner systems. The primary component of this system is a layer of geonet that allows gases and vapors generated by the wastepile mass to flow to vents. The other component of the gas transmission system is a layer of geotextile between the soil cover and the geonet. The geotextile layer serves as a filter fabric, which allows gas and vapors to flow into the geonet but prevents soil from clogging the pores of the geonet.

The gas transmission system is overlain by a geomembrane, which serves as a very low permeability barrier to prevent infiltration of water into the wastepile.

The geomembrane layer is overlain by the drainage layer system. The primary component of the drainage layer system is a geonet layer that allows water percolating through the overlying soil layers to flow over the surface of the geomembrane and exit through drains at the toe of the wastepile side slope. The drainage layer system prevents a liquid head from developing over the geomembrane and prevents saturation of the overlying soil layers, which would result in decreased slope stability of the soil layers on the wastepile side slopes. The other component of the drainage layer system is the geotextile layer, which overlies the geonet layer and prevents soil from clogging the pores of the geonet.

The existing drainage layer system is overlain by a 1-ft soil layer. The soil layer protects the geosynthetic components of the drainage layer, geomembrane, and gas transmission systems during placement and compaction of the cohesive cover. The cohesive cover is a 1-ft layer of fine-grained silt and clay soil. The function of the cohesive cover is to minimize the infiltration of rainfall through the soil layers. The cohesive cover is overlain by a 6-inch layer of topsoil. The topsoil layer supports a vegetative cover for the wastepile cover system, which prevents damage from erosion by stormwater runoff.

This medium group is not considered a source of groundwater contamination, but the long-term groundwater protection offered by the existing liner system is uncertain since leachate has been detected in the leachate detection layer. Therefore, the evaluation of alternatives in the following sections considers the ability of each alternative to improve the performance of the existing containment system or to address the uncertainty regarding its long-term effectiveness.

Table 11.1-1 provides a summary of contaminants, concentrations, and exceedance values for this medium group. Maximum concentrations of OCPs, CLC2A, and VOCs exceed the Human Health SEC, and the maximum concentration of dieldrin is above the principal threat criteria (10^{-3} excess cancer risk, HI of 1,000). Concentrations of arsenic and mercury exceed the Biota SEC, but are contained in the human health exceedance area. The concentrations of contaminants in this medium group were inferred from RI sampling at Basin F prior to the implementation of the

IRA. In addition, the wastepile materials contain percent levels of salts due to the high chloride content in wastewater stored in the former Basin F. 580,000 BCY of contaminated soils and sludges were placed in the wastepile as part of the IRA. The exceedance volume for this subgroup is 600,000 BCY, which accounts for the contaminated materials in the leachate systems and subgrade.

The Basin F Wastepile Medium Group has poor-quality habitat, and large mammals and burrowing animals are currently excluded from the area through fencing. The alternatives that consist of excavating and treating the wastepile result in an improvement in habitat quality following revegetation. The remaining alternatives, which consist of continuing to exclude various species of animals, do not result in an improvement in habitat quality, and mitigation is required to replace the lost habitat. Coordination with groundwater alternatives is not required since no groundwater alternatives are being evaluated in the immediate vicinity of the wastepile.

11.2 EVALUATION OF ALTERNATIVES

The five alternatives for the Basin F Wastepile Medium Group vary in approach from no action to containment and treatment. The alternatives retained in the DSA for this medium group were not modified except to indicate that solidification is not required following the treatment of organic contaminants. Solvent washing was screened out in the DSA in favor of thermal desorption based on cost and effectiveness concerns. However, ongoing treatability studies have demonstrated that solvent washing could effectively remove OCPs. In addition, the high salt content of the wastepile materials would increase the cost of thermal desorption due to fouling, but would not impact the cost of solvent washing significantly. As a result, solvent washing has been reintroduced into the FS for the wastepile as Alternative 8a: Direct Soil Washing (Solvent Washing). The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA.

11.2.1 Alternative 1: No Additional Action

Alternative 1: No Additional Action (Provisions of FFA) applies to the 75,000 SY of exceedance area in the Basin F Wastepile Medium Group. The 580,000 BCY of exceedance volume contained in the wastepile remains in place and no controls are implemented. No additional actions (beyond the existing fence and cover) are taken to reduce potential human or biota exposure to COCs. As part of this alternative, a blocked sump in the existing leachate collection system is modified by installing an adjacent 6-inch inside-diametermonitoring/extraction well. The improvement of the sump in Cell 2 may entail more intrusive actions such as replacing the gravel in the sump or modifications to the sump itself. The installation of an adjacent 6-inch monitoring/extraction well is included in this alternative as a base case for modifying the sump. This modification allows for the monitoring of leachate levels in the primary sump, improves the collection and removal of leachate, and decreases the leachate head on the primary geomembrane liner layer. An average long-term leachate volume of 50,000 gallons per year is pumped from the wastepile leachate collection and leak detection systems. The leachate is drummed and shipped off post for incineration. Long-term maintenance is required to maintain the integrity of the existing liner and cap. Five-year site reviews are conducted to assess the integrity of the wastepile cover and the potential migration of contaminants.

Table 11.2-1 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health RAOs by interrupting human health exposure pathways through the existing controls, but the existing controls do not completely achieve Biota RAOs, so residual risk is low. The long-term protection of groundwater is uncertain since the existing cover reduces, but does not eliminate, infiltration. The poor-quality habitat is not improved by this alternative, and biota continues to be excluded by the existing fencing. The total estimated present worth cost of this alternative is $30,500,000 based on a leachate treatment rate of 50,000 gallons per year. Table B4.2-1 details the costing for this alternative.

11.2.2 Alternative 2: Access Restrictions

Alternative 2: Access Restrictions (Modifications to FFA) leaves 580,000 BCY of exceedance soils and sludges in the wastepile contained in place. In addition to the existing restrictions of a fence and an interim cover, exclusion of biota from the wastepile is promoted by revegetation with grasses unappealing to biota. Revegetation of 75,000 SY is accomplished over a 3-year period, and long-term maintenance is performed on the vegetation and the existing fence. The importance of maintaining and respecting access restrictions to prevent inadvertent exposures is presented in an ongoing public education program. A blocked sump in the existing leachate collection system is modified by installing an adjacent 6-inch inside-diameter extraction well. This action is included in this alternative as a base case for modifying the sump; it allows for monitoring of leachate levels in the primary sump, and collection and removal of leachate to reduce the leachate head on the primary geomembrane liner layer. However, the improvement of the sump in Cell 2 may entail more intrusive actions such as replacing the gravel in the sump or modifications to the sump itself. An average long-term leachate volume of 50,000 gallons per year is pumped from the wastepile. The leachate is drummed and shipped off post for incineration. Long-term maintenance is required to maintain the integrity of the existing liner and the cap. Five-year site reviews are conducted to review the effectiveness of the alternative, to assess the integrity of the wastepile cover, and to assess natural attenuation/degradation and the potential migration of contaminants.

Table 11.2-2 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs by interrupting exposure pathways, so there is a low residual risk of exposure. However, the long-term protection of groundwater is uncertain. The existing poor-quality habitat is not improved and biota continues to be excluded through fencing and controls. The total estimated present worth cost of this alternative is $31,000,000 based on a leachate treatment rate of 50,000 gallons per year. Table B4.2-2 details the costing for this alternative.

11.2.3 Alternative 6e: Caps/Covers

Alternative 6e: Caps/Covers (Composite Cap) addresses the Basin F Wastepile through the installation of a 75,000-SY composite cap to augment the existing cover. Section 4.6.8 discusses caps in detail. The existing soil cover is compacted as the subgrade for the composite cap. The composite cap consists of (from the bottom up) a geogrid, a 4-ft compacted low permeability soil layer, a 100-mil FML, a 1-ft-thick sand drainage layer, an additional geosynthetic filter layer, a biota barrier of cobbles, and a 4-ft soil/vegetation layer that includes 6 inches of topsoil. The cap is completed by revegetation of the topsoil. The fill materials are excavated from borrow areas located on post, and topsoil, cobbles, and sand are obtained off post. The borrow area is regraded and revegetated to restore habitat.

As discussed above, a blocked sump in the existing leachate collection system is modified by installing an adjacent 6-inch inside-diameter monitoring/extraction well. This action is included in this alternative as a base case for modifying the sump; it allows for monitoring of leachate levels in the primary sump and collection and removal of leachate to reduce the leachate head on the primary geomembrane liner layer. However, the improvement of the sump in Cell 2 may require more intrusive actions such as replacing the gravel in the sump or modifications to the sump itself. Following dewatering of the wastepile over the next few years, the average long-term leachate volume of 550 gallons per year is pumped from the leachate collection system after the installation of the composite cap. The leachate is drummed and shipped off post for incineration. The composite cap provides a physical barrier to protect human and biota receptors from directly contacting contaminated soil and sludge. The cap also reduces the potential for migration of contaminants from the wastepile to groundwater by reducing infiltration into the wastepile. Maintenance activities such as mowing and replacement of eroded soils ensures the continued integrity of the composite cap containment system. Five-year site reviews are conducted to review the effectiveness of the alternative and to assess natural attenuation/degradation and potential migration of contaminants.

Table 11.2-3 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs, including the long-term protection of groundwater, through the installation of a composite cap over the existing cover to reduce infiltration. Contaminant mobility is reduced and exposure pathways are interrupted. Although the cap is revegetated with native grasses, biota are still excluded from the wastepile, which does not impact the existing habitat quality. Long-term maintenance is required. The installation of a 75,000-SY composite cap is accomplished within 1 year. The total estimated present worth cost of this alternative is $9,200,000 based on the reduced leachate treatment rate of 550 gallons per year resulting from improvements to the cap system. Table B4.2-6e details the costing for this alternative.

11.2.4 Alternative 8a: Direct Soil Washing

Alternative 8a: Direct Soil Washing (Solvent Washing); treats 600,000 BCY of contaminated soils through the solvent washing process, which has been reintroduced into the DAA as described in Section 11.2. The excavation of the wastepile for treatment involves the removal of the existing cover (75,000 BCY) as overburden material. Volatile emissions and noxious odors are controlled during excavation by enclosing the wastepile with an air-supported vapor enclosure. The structure is fabricated from a synthetic fabric coated to achieve zero porosity. The structure is supported by an internal pressure of 0.10 pounds per square inch gauge (psig) and is designed to withstand wind velocities of 80 miles per hour and a snow load of 4 ft. A wet scrubber system is used to remove contaminants from the airspace within the structure. The aqueous solutions from the wet scrubber system are alkaline and are treated through mixture with the acidic blowdown water from the thermal desorber and subsequent treatment at the CERCLA Wastewater Treatment Plant. Following excavation, the liner system components are removed, shredded, washed, and placed in the on-post landfill.

Since all of the soils and sediments in the wastepile contain high levels of salts, 600,000 BCY of materials are treated by solvent washing as part of this alternative. Nine washing cycles are required to achieve Human Health and Biota PRGs, but the solvent is recycled between washing

cycles and treated through distillation (Section 4.6.19). A total of 360,000 gallons of liquid effluent are generated and treated at an off-post commercial facility as part of solvent washing. A total of 30 solvent washing units are required to maintain a throughput of approximately 1,200 BCY/day. The treated soil is backfilled and covered with topsoil to promote revegetation with native grasses.

Table 11.2-4 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs, including the long-term protection of groundwater, since all contaminated soils are treated to remove or destroy the exceedance COCs. The residual risk achieves PRGs. The solvent washing of 600,000 BCY of contaminated soils requires approximately 2 years, and the habitat is improved following treatment. The 360,000 gallons of liquid effluent generated by solvent washing is treated off post. The total estimated present worth cost of this alternative is $260,000,000. Table B4.2-8 details the costing for this alternative.

11.2.5 Alternative 9a: Direct Soil Washing; Direct Thermal Desorption

Alternative 9a: Direct Soil Washing (Solution Washing); Direct Thermal Desorption (Direct Heating) treats 600,000 BCY of contaminated soils through a combination of these two technologies as described in Section 4.5.

The excavation of the wastepile for treatment involves the removal of the existing cover (75,000 BCY) as overburden material. Volatile emissions and noxious odors are controlled during excavation by enclosing the wastepile with an air-supported vapor enclosure. The structure is fabricated from a synthetic fabric coated to achieve zero porosity. The structure is supported by an internal pressure of 0.10 psig and is designed to withstand wind velocities of 80 miles per hour and a snow load of 4 ft. A wet scrubber system is used to remove contaminants from the airspace within the structure. The aqueous solutions from the wet scrubber system are alkaline and are treated through mixture with the acidic blowdown water from the thermal desorber and

subsequent treatment at the CERCLA Wastewater Treatment Plant. Following excavation, the liner system components are removed, shredded, washed, and placed in the on-post landfill.

Since all of the soils and sediments in the wastepile contain high levels of salts, 600,000 BCY of materials are treated by soil washing as part of this alternative. The four-stage soil washing equipment is capable of treating 14 BCY/hr. The processing rate for soil washing is the limiting factor for overall alternative throughput. The washing solutions consist of dilute surfactant and flocculant solutions that remove the high levels of salts and most of the CLC2A. The spent effluent solutions are treated at an expanded CERCLA wastewater facility.

The 600,000 BCY of soils treated by soil washing are further treated by thermal desorption, since the soils still contain high levels of OCPs, volatiles, and DCPD. Soil washing removes most of the CLC2A and salts, which decreases corrosion of the refractory lining of the thermal descrber. The thermal desorption facility requires approximately 1 year to build, and the testing of the thermal desorber requires an additional year. The moisture content of soils exiting the soil washer is 20 percent. Due to this high moisture content, the thermal desorber has a soils processing rate of approximately 1,300 BCY/day. The thermal desorber operates with a soils discharge temperature of 300°C and a residence time of 50 minutes. Section 4.6.24 discusses emission controls for off gases from thermal desorption. Approximately 6,000 BCY (or 1 percent of the total soils feed) are recovered as particulates from the scrubber blowdown and are placed in the on-post hazardous waste landfill. The treated soils are returned to the former Basin F as backfill and are covered with the wastepile overburden since thermal treatment destroys the organic carbon in the treated soils. Revegetation of the disturbed areas with native grasses results in an increase in the habitat quality compared to the existing conditions.

Table 11.2-5 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs, including the long-term protection of groundwater, since all contaminated soils are treated to remove or destroy the exceedance COCs. Residual risk achieves PRGs. The soil washing and thermal desorption of

600,000 BCY of contaminated soils requires approximately 8 years, and the habitat is improved following treatment. The effluent generated by soil washing is treated in a bioreactor as part of the soil washing process. The total estimated present worth cost of this alternative is $230,000,000. Table B4.2-9 details the costing for this alternative.

11.2.6 Alternative 13a: Direct Thermal Desorption

Alternative 13a: Direct Thermal Desorption (Direct Heating) treats 600,000 BCY of soils primarily contaminated with OCPs, VOCs, CLC2A, and dicyclopentadiene (DCPD) by direct thermal desorption as described in Section 4.5. This alternative differs from Alternative 9a in that soil washing is not used as a pre-treatment to remove salts and CLC2A prior to thermal treatment.

The remediation of the wastepile requires the excavation of 75,000 BCY of overburden materials. As discussed for Alternative 9a, volatile emissions and noxious odors are controlled during excavation by enclosing the wastepile with an air-supported structure. A wet scrubber system is used to remove contaminants from the airspace within the structure, which generates an aqueous solution requiring treatment. Following excavation, the liner system components of the wastepile, which have been contaminated by the generated leachate, are removed, shredded, and placed in the on-post landfill.

The thermal desorber requires approximately 2 years to build and an additional year for testing. For the wastepile soils, which have a moisture content of approximately 20 percent, the thermal desorber has a processing rate of approximately 1,300 BCY/day. Soil is discharged at a temperature of 300°C after a soils residence time of 50 minutes. (Section 4.6.24 discusses emission controls for off gases from thermal desorption.) Approximately 6,000 BCY (or 1 percent of the total soils feed) are recovered as particulates from the scrubber blowdown and are placed in the on-post landfill. The operating costs for thermal desorption are increased by 30 percent for this subgroup due to fouling caused by the high salt content of the soils. The treated soils are returned to the former Basin F as backfill and are covered with the wastepile

overburden. Since thermal desorption destroys the natural organic content of the soils, the disturbed areas are restored by revegetation with native grasses.

Table 11.2-6 presents the evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs, including the long-term protection of groundwater, since all contaminated soils are treated to destroy the exceedance COCs. Residual risk achieves PRGs. The habitat is improved at the site following remediation. The thermal desorption of 600,000 BCY of contaminated soils requires approximately 4 years, which includes the 2 years required for the construction and testing of the facility. The total estimated present worth cost of this alternative is $210,000,000. Table B4.2-13a details the costing for this alternative.

11.3 SELECTION OF PREFERRED ALTERNATIVE

The Basin F Wastepile Medium Group consists of 580,000 BCY of contaminated sludges and soils removed from Basin F and placed in a wastepile during the Basin F IRA and an additional 20,000 BCY of contaminated materials in the leachate systems and subgrade. As discussed in Section 11.1, this medium group consists of a composite cover, a leachate collection layer, and a leachate detection layer or secondary layer. The wastepile consists of three individual cells, each of which contains a leachate sump for the primary and secondary leachate collection layers. A chain-link fence surrounds the wastepile to further limit exposure pathways beyond the physical barrier provided by the composite cap.

The materials in the wastepile primarily contain OCPs, although volatile organics and CLC2A are also COCs. In addition, the materials in the wastepile contain ammonia and parts per hundred levels of salts. These constituents are not COCs, but their presence impacts the performance of several technologies and, consequently, the evaluation of remedial alternatives. Samples of materials in the wastepile were not collected for chemical analysis during the Basin F IRA, but samples of the sludge material and underlying soils were analyzed before the IRA was initiated. These samples indicate that the materials within the wastepile contain high levels

of contamination (in the range of 10,000 ppm total OCPs), although specific contaminant distributions are not available. The entire volume of the Basin F wastepile is considered to meet the principal threat criteria since the pre-IRA samples exceeded the principal threats criteria for several of the OCPs.

The presence of high levels of OCPs and volatiles along with ammonia indicates that extensive controls are required for the protection of site workers for remedial actions that involve excavation of the wastepile. Extensive monitoring is required to evaluate potential community exposure, and odor control management might be required to mitigate community concerns. Site workers involved in excavation require Level B protection, which includes supplied air, and the excavation is conducted within a vapor enclosure (which is discussed in Section 11.2) to control the release of vapors and odors from the excavation. These controls reduce the productivity of excavation operations and substantially increase the cost and difficulty of excavation operations. Because there are no containerized materials or UXO in the wastepile, these controls can adequately protect the community and site workers.

The wastepile was constructed within the areal extent of Basin F, which was devegetated and did not provide any useable habitat. The habitat quality of the wastepile is poor based on the vegetation type of the composite cover. The fencing associated with the wastepile further limits the usage of the site for habitat. As such, disturbance of the vegetation associated with any additional remedial actions conducted for the wastepile would not reduce available habitat.

Leachate has been removed from each of the cells since completion of the IRA and pumped to the Basin F Liquid Storage area for subsequent treatment. The primary leachate collection layer and associated sump for Cell 2 is currently not producing any leachate and appears to be plugged; however, leachate is being removed from the secondary layer of Cell 2. Measures to correct the apparent plugging are currently being evaluated, as are part of the alternatives for the wastepile that involve modifying the existing containment system. The amount of leachate removed from all three cells is within the allowable limits established by EPA for landfills.

Since the secondary containment system for Cell 2 is currently functioning as the primary system for collecting leachate, Cell 2 does not have a redundant containment layer; however, the potential impacts on groundwater are minimal based on the small volume of leachate being collected for Cell 2, and activities to correct the clogging of the primary leachate system are being evaluated.

In summary, the wastepile is currently adequately contained to isolate the contaminants and protect human health and the environment, although the leachate collection system for Cell 2 needs to be corrected. In selecting the preferred remedial alternatives, the potential long-term risks of contaminant migration if the wastepile is left in place must be balanced against the short-term risks of work in Level B in a confined space and against potential community concerns. Additionally, the time needed to complete a containment alternative (1 year) is significantly shorter than the time that would be required for excavation and treatment (4-8 years), during which time the exposure risks discussed above are extant.

Alternative 1: No Additional Action and Alternative 2: Access Restrictions are protective of human health as the existing containment system interrupts exposure pathways. However, Alternative 1 is not protective of biota and both Alternative 1 and 2 do not improve the long-term protection of the groundwater. These alternatives are therefore eliminated from further consideration as the preferred alternative. The four remaining alternatives include a containment alternative and three treatment alternatives. All four of these alternatives achieve RAOs, and they are protective of human health and the environment and comply with action-specific and location-specific ARARs, thereby satisfying the threshold criteria. The alternatives are distinguished by the five balancing criteria (Tables 11.2-1 through 11.2-6).

Alternative 8a: Direct Soil Washing, Alternative 9a: Direct Soil Washing; Direct Thermal Desorption, and Alternative 13a: Direct Thermal Desorption require a vapor enclosure and air treatment system during excavation and have significantly higher costs ($260,000,000, $230,000,000, and $210,000,000, respectively) than the containment alternative, Alternative 6e:

Caps/Covers ($9,200,000). Limited vendor sources are available for the soil washing equipment required for Alternative 8a: Direct Soil Washing and Alternative 9a: Direct Soil Washing; Direct Thermal Desorption, and both require the treatment of a large liquid sidestream. Alternative 6e: Caps/Covers achieves RAOs, including long-term protection of groundwater, through minimization of infiltration, and does not require the excavation of the wastepile. Therefore, this alternative exhibits lower short-term impacts during remedial actions.

The preferred alternative for the Basin F Wastepile Medium Group is Alternative 6e: Caps/Covers. This alternative is protective of human health and the environment by eliminating exposure pathways and preventing groundwater contamination. The installation of a composite cap does not require the extensive vapor controls nor does it require the excavation procedures involved in the other treatment alternatives. Moreover, the installation of the cap costs more than an order of magnitude less than the treatment alternatives. Alternative 6e: Caps/Covers avoids potentially severe short-term impacts to the site workers, and possibly to the community, that result from the excavation of the wastepile. Therefore, Alternative 6e: Caps/Covers is considered the most cost-effective alternative for the Basin F Wastepile.

The NCP (EPA 1990) indicates that treatment alternatives should be selected for materials considered principal threats, wherever practicable, and that engineering controls are appropriate for principal threats where treatment is inappropriate. EPA guidance on principal threats (EPA 1991a) indicates that treatment may not be appropriate in those instances for which the implementation of the treatment-based alternative results in a greater overall risk to human health and the environment due to the risks posed to site workers and the community during the remedial action. The excavation of the wastepile for treatment would result in a greater risk to workers and the community than Alternative 6e: Caps/Covers, and the installation of a composite cap is still protective of human health and the environment. As indicated in the referenced guidance and the preamble to the NCP (EPA 1990), the selection of Alternative 6e: Caps/Covers for the Basin F Wastepile Medium Group is an appropriate exception to the guidance regarding the treatment of principal threats.

Table 11.0-1 Characteristics of the Basin F Wastepile Medium Group[1]

Characteristic	Basin F Wastepile Medium Group
Contaminants of Concern	
Human Health	OCPs, volatiles, CLC2A, DCPD
Biota	none
Exceedance Area (SY)	
Total	75,000
Human Health	75,000
Biota	0
Potential Agent	not applicable
Potential UXO	not applicable
Exceedance Volume (BCY)[2]	
Total	580,000
Human Health	580,000
Organic	580,000
Inorganic	0
Principal Threat	580,000
Biota	0
Potential Agent	not applicable
Potential UXO	not applicable
Depth of Contamination (ft)	
Human Health	not applicable
Biota	not applicable

1 Basin F Wastepile is aboveground and contains material from the former Basin F.

2 Approximately 20,000 BCY of additional contaminated materials in the leachate system and subgrade would also require excavation for alternatives involving excavation of the Basin F Wastepile.

Tab[illegible].1-1 Summary of Concentrations for the Basin F Waste[illegible]Medium Group

Contaminants of Concern	Range of Concentrations (ppm)	Average Concentration (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC (ppm)
Human Health Exceedance Volume					
Aldrin	0.1-3,100	Not Available	56	560	0.68
Dieldrin	0.1-700	Not Available	40	400	0.83
Endrin	9.2-900	Not Available	15	15,000	0.03
Isodrin	3.16-3,000	Not Available	3.4	3,400	not applicable
CLC2A	110-760	Not Available	74	74,000	not applicable
1,2-Dichloroethane	3,4-110	Not Available	340	3,400	not applicable
DCPD	1,500-2,000	Not Available	1,200	1,000,000	not applicable
Biota Exceedance Volume					
None		not applicable	not applicable	not applicable	not applicable

[1] Concentrations inferred from remedial investigations sampling at NCSA-3 prior to Basin F interim response action.

Table 11.2-1 Evaluation of Alternative 1: (Provisions of FFA) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Achieves Human Health but not Biota RAOs as untreated soils remain without additional biota controls implemented. Long-term reduction in toxicity of contaminants through natural attenuation; long-term protection of groundwater uncertain due to cover construction and potential contaminant migration through leachate generation.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-10, and A-23)	a) Complies with action-specific ARARs as site reviews performed; soil sampling not conducted in order to preserve integrity of wastepile cover.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Wastepile not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. High levels of OCPs, volatiles, CLC2A, and DCPD above Human Health SEC and principal threat criteria remain, but exposure pathways are interrupted through engineering controls of wastepile.
b) Adequacy and reliability of controls	b) No additional controls implemented. Site reviews, groundwater monitoring, and leachate treatment required.
c) Habitat impacts	c) Habitat quality not improved. Existing poor-quality habitat not impacted and biota exclusions retained by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated but wastepile contained. No reduction in contaminant volume or mobility; 580,000 BCY of untreated soils and sludges remain contained in wastepile.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or vapor emissions.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Existing poor-quality habitat not impacted by remedial alternative; long-term protection of groundwater uncertain.
d) Time until RAOs are achieved	d) >30 years. Human exposure pathways interrupted by existing cover.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Monitoring services readily available.

CRITERIA		ALTERNATIVE EVALUATION
7. Present worth costs		
a) Capital		a) $0
b) Operating		b) $21,000
c) Long-term		c) $30,000,000
d) Total		d) $30,000,000

Table 11.2-2 Evaluation of Alternative 2: Access Restrictions (Modifications to FAA) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs as human and biota exposure pathways interrupted through access restrictions and biota controls; long-term protection of groundwater uncertain.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Table A-5)	a) Complies with action-specific ARARs as access controlled and site reviews conducted; soil sampling not conducted to preserve the integrity of the wastepile cover.
b) Location-specific ARARs See Soils DSA, Volume II Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Wastepile not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. High levels of OCPs, volatiles, CLC2A, and DCPD above Human Health SEC and principal threat criteria remain, but exposure pathways interrupted through engineering controls of wastepile; fencing, land-use restrictions, and cultivation of lower-quality habitat reduce human health and biota exposure to contaminants.
b) Adequacy and reliability of controls	b) Adequate controls. Installation of fencing and land-use restrictions reduce human exposure; controls adequate for small area; site reviews, long-term maintenance, monitoring of wildlife exclusion, groundwater monitoring, and leachate treatment required.
c) Habitat impacts	c) Habitat quality not improved. Biota controls of fencing and cultivation of lower-quality habitat further eliminate habitat for biota.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated but wastepile contained. No reduction of containment volume or mobility for 580,000 BCY of soils beyond existing containment of wastepile: human and biota exposure pathways interrupted over 75,000 SY by engineering controls of wastepile, land-use restrictions, fencing, and biota controls
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Exposure controls reversible if fencing or biota controls fail.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative. Contaminants remain in place.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during fence installation and cultivation of lower-quality habitat.
b) Protection of community during remedial action	b) Protective of community. Dust and vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat and biota exclusions; potential migration of contaminants to groundwater in long term not reduced.
d) Time until RAOs are achieved	d) 3 years. Installation of perimeter fencing feasible within 1 year. Cultivation of lower-quality habitat requires 3 years.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably maintained thereafter; additional remedial actions easily undertaken for soils left in place, although existing cap would require removal.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment readily available for sump modification and habitat modifications.

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) \$3,000
b) Operating	b) \$62,000
c) Long-term	c) \$30,000,000
d) Total	d) \$31,000,000

Table 11.2-3 Evaluation of Alternative 6e: Caps/Covers (Composite Cap) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; existing cover on wastepile augmented by composite cap, which prevents exposure; potential groundwater impacts and leachate generation reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Table A-5)	a) Complies with action-specific ARARs regarding construction of RCRA covers and monitoring of contained material.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Wastepile not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 580,000 BCY of untreated soils contained with 75,000-SY composite cap.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring, site reviews, and leachate treatment required for untreated soils; erosion control and vegetative cover maintenance required; high confidence in engineering controls of composite cap.
c) Habitat impacts	c) Habitat quality not improved. Existing poor-quality habitat not improved and biota exclusions not removed by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Wastepile containment augmented, exposure pathways interrupted, and mobility of contaminants reduced through installation of 75,000-SY composite cap.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if cap degrades or leaks.
d) Type and quantity of treatment residuals	d) Leachate from wastepile shipped off post for treatment.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during installation of composite cap.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat and existing biota exclusions; potential migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 1 year. Installation of 75,000-SY composite cap feasible within 1 year.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably maintained thereafter; additional remedial actions easily undertaken for soils left in place, although cap adds to overall site volume.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of cap/cover design and construction regulations.
c) Availability of services and materials	c) Readily implemented. Soil materials, equipment, and specialists readily available for composite cap construction; composite caps well demonstrated at full scale.

Table 11.2-3 Evaluation of Alternative 6e: Caps/Covers (Composite Cap) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $5,700,000
c) Long-term	c) $3,500,000
d) Total	d) $9,200,000

Table 11.2-4 Evaluation of Alternative 8a: Direct Soil Washing; (Solution Washing) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to organic detection levels and inorganics reduced below Biota SEC; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-10, and A-23)	a) Complies with action-specific ARARs as state regulations on air emission sources achieved.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Wastepile, treatment facilities, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 600,000 BCY treated by solvent washing and returned to site as backfill; 360,000 gallons of liquid effluent from solvent washing drummed and transported off-post for treatment.
b) Adequacy and reliability of controls	b) Adequate controls. Backfill monitoring not required.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 600,000 BCY solvent washed to degrade OCPsand remove salts.
b) Degree and quantity of TMV reduction	b) Organics reduced below PRGs (>99.99% destructive removal efficiency). TMV of organics eliminated.
c) Irreversibility of TMV reduction	c) TMV reduction by solvent washing irreversible.
d) Type and quantity of treatment residuals	d) 360,000 gallons of liquid effluent from solvent washing drummed and transported off-post for treatment.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Extensive personnel protective equipment and vapor treatment system equipment required to adequately protect workers during excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor and odor emissions not anticipated from solvent washing; vapor emissions associated with excavation controlled by vapor enclosure and air emissions control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impact. Minimal impact on biota due to existing poor-quality habitat; potential migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 2 years. Excavation and treatment of 600,000 BCY feasible within 2 years based on a facility of 30 solvent washing units.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter, but 30 treatment units required for facilitiy; vapor enclosure required during excavation.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment units siting, design, and operating regulations.
c) Availability of services and materials	c) Available. Limited vendor sources available for solvent washing unit; demonstrated at full scale but for units with limited throughout.

Table 11.2-4 Evaluation of Alternative 8a: Direct Soil Washing; (Solution Washing) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $100,000,000
b) Operating	b) $160,000,000
c) Long-term	c) $0
d) Total	d) $260,000,000

Table 11.2-5 Evaluation of Alternative 9a: Direct Soil Washing; (Solution Washing); Direct Thermal Desorption (Direct Heating) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to organic detection levels; blowdown solids placed in on-post landfill; potential groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-10, and A-23)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Wastepile, treatment facilities, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 600,000 BCY treated by soil washing and thermal desorption and returned to site as backfill; approximately 1% of soils feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Backfill monitoring not required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 600,000 BCY soil washed to remove salts and thermally desorbed to degrade OCPs, volatiles, CLC2A, and DCPD.
b) Degree and quantity of TMV reduction	b) Organics reduced below detection levels (>99.99% destructive removal efficiency); TMV of organics eliminated; scrubber blowdown solids from off-gas treatment equipment with salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible.
d) Type and quantity of treatment residuals	d) 6,000 BCY of blowdown solids with salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Extensive personnel protective and vapor treatment system equipment required to adequately protect workers during excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor and odor emissions from excavation controlled by enclosure with vapor treatment systems; vapor emissions associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impact. Minimal impact on biota due to existing poor-quality habitat; potential migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 8 years. Excavation and treatment of 600,000 BCY feasible within 6 years after 2 years for construction thermal desorption facility and landfill, based on throughput of soil washer.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; vapor enclosure required during excavation; landfill cell monitored; treatment of liquid sidestream as part of soil washing process.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment systems and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Limited vendor sources available for soil washing unit; several vendor sources available for design and construction of thermal desorbers; equipment, specialists, and materials readily available for design and construction of thermal desorbers; equipment, specialists, and materials readily available for construction of landfill vapor enclosures that are available from several sources; thermal desorbers, soil washing, and landfills well demonstrated at full scale.

Table 11.2-5 Evaluation of Alternative 9a: Direct Soil Washing; (Solution Washing); Direct Thermal Desorption (Direct Heating) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $100,000,000
b) Operating	b) $130,000,000
c) Long-term	c) $0
d) Total	d) $230,000,000

Table 11.2-6 Evaluation of Alternative 13a: Direct Thermal Desorption (Direct Heating) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to organic detection levels; blowdown solids placed in on-post landfill; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, A-10, and A-23)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Wastepile, thermal desorption facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 600,000 BCY thermally desorbed and returned to site as backfill; approximately 1% of soils feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Backfill monitoring not required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 600,000 BCY thermally desorbed to degrade OCPs, volatiles, CLC2A, and DCPD.
b) Degree and quantity of TMV reduction	b) OCPs, volatiles, CLC2A, and DCPD reduced to below detection levels (>99.99% destruction removal efficiency); TMV of organic compounds eliminated; scrubber blowdown solids from off-gas treatment equipment with salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible.
d) Type and quantity of treatment residuals	d) 6,000 BCY of blowdown solids with salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Extensive personnel protective and vapor treatment system equipment required to adequately protect workers during excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor and odor emissions from excavation controlled by vapor enclosure with vapor treatment systems; vapor emissions associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; potential migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 4 years. Excavation and treatment of 600,000 BCY feasible within 2 years after 2 years for construction thermal desorption facility and landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cell monitored; vapor enclosure required during excavation.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment systems and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers; equipment, specialist, and materials readily available for construction of landfill and vapor enclosures; thermal desorbers and landfills well demonstrated at full scale.

Table 11.2-6 Evaluation of Alternative 13a: Direct Thermal Desorption (Direct Heating) for the Basin F Wastepile Medium Group

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $96,000,000
b) Operating	b) $120,000,000
c) Long-term	c) $20,000
d) Total	d) $210,000,000

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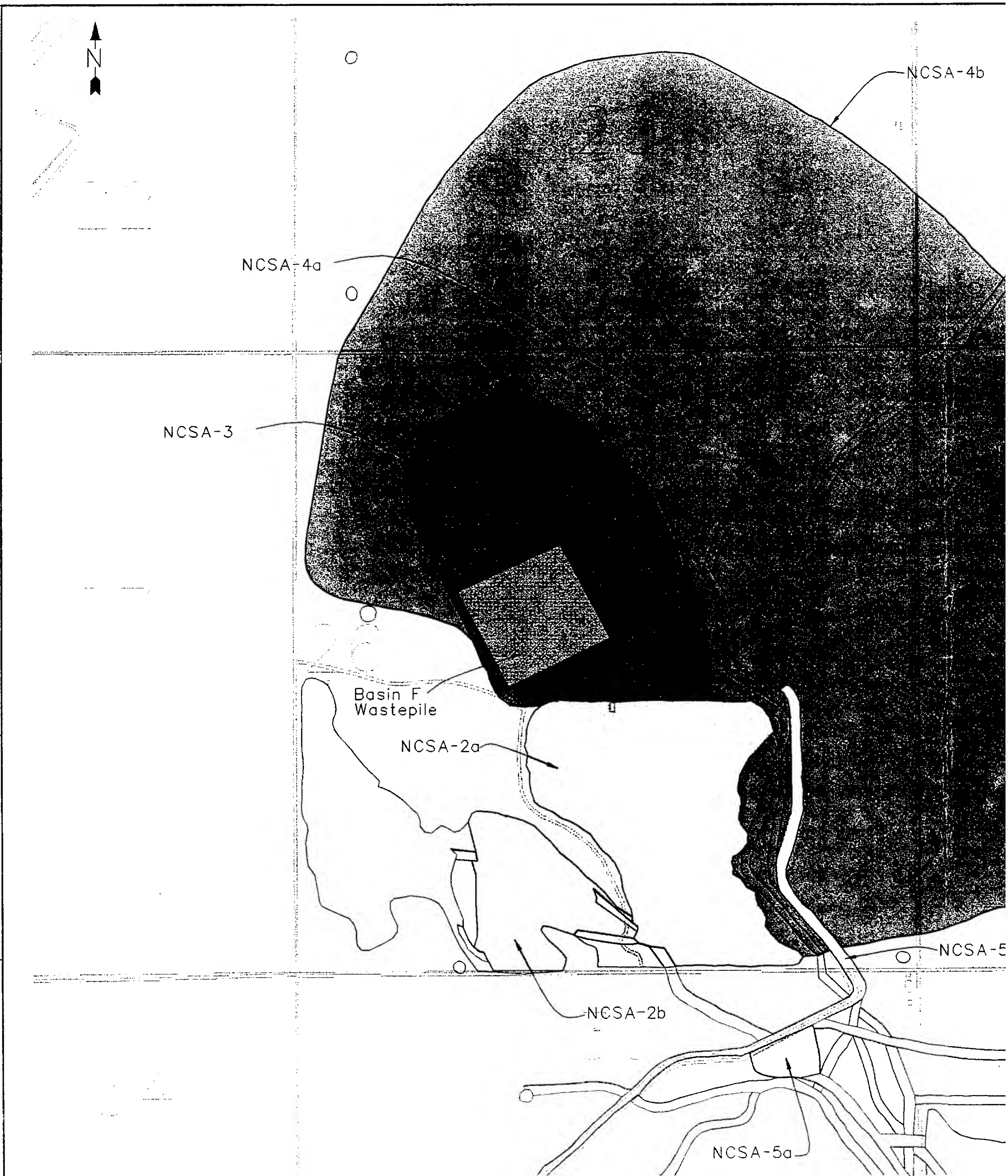
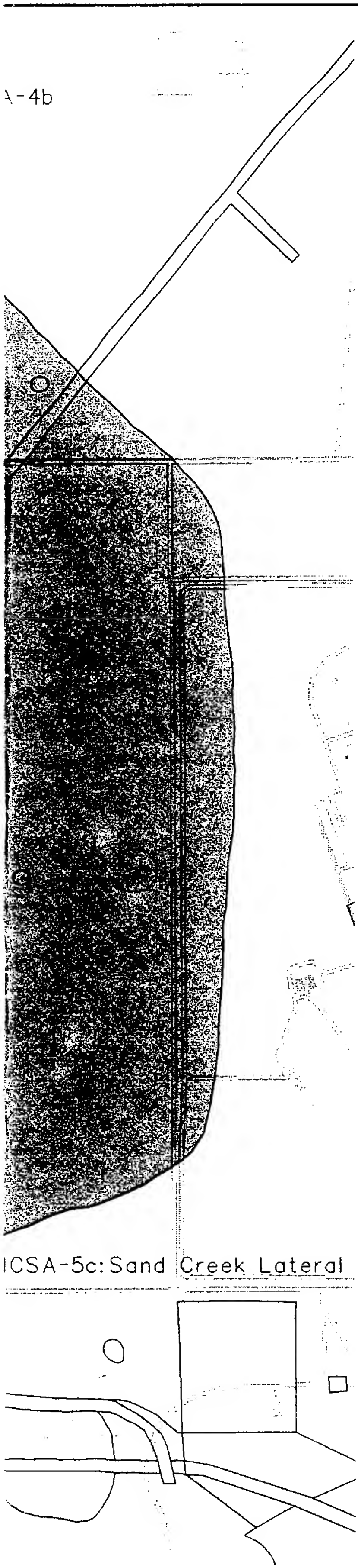
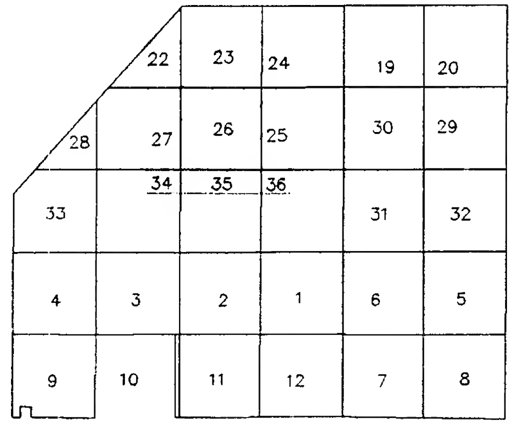




ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Secondary Basins Subgroup
SITE: NCSA-2a, Basin C
NCSA-2b, Basin D
NCSA-5a, Basin B

Former Basin F Subgroup
SITE: NCSA-3, Former Basin F

Basin F Exterior Subgroup
SITE: NCSA-4a, Deep Disposal Well
NCSA-4b, Basin F Exterior

Basin F Wastepile Medium Group
SITE: Basin F Wastepile

Site Boundary

Buildings and Roads

Section Number

500 0 500 1000 FEET

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 12.0-1

Site Locations
Secondary Basins Medium Group

Rocky Mountain Arsenal.
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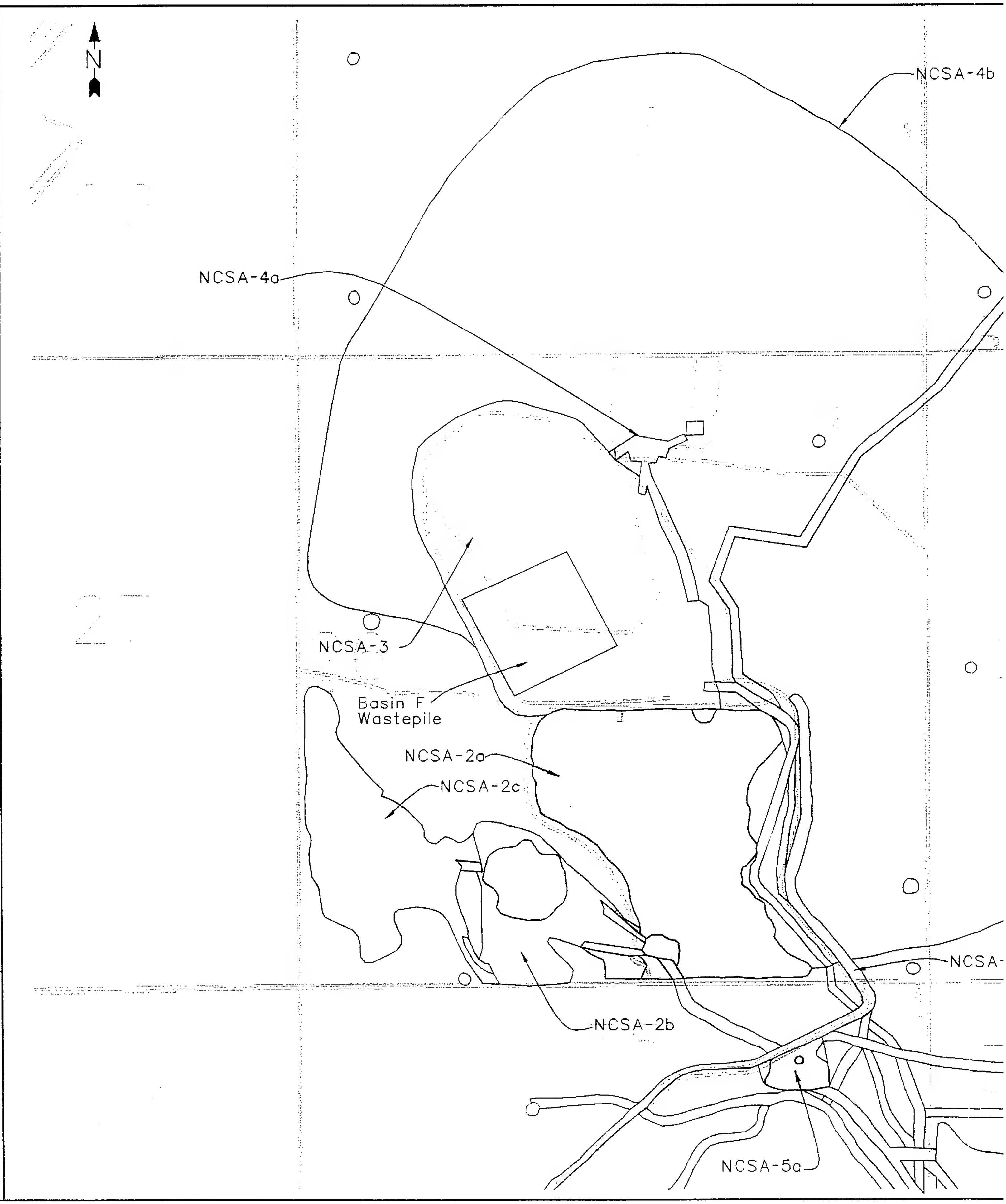
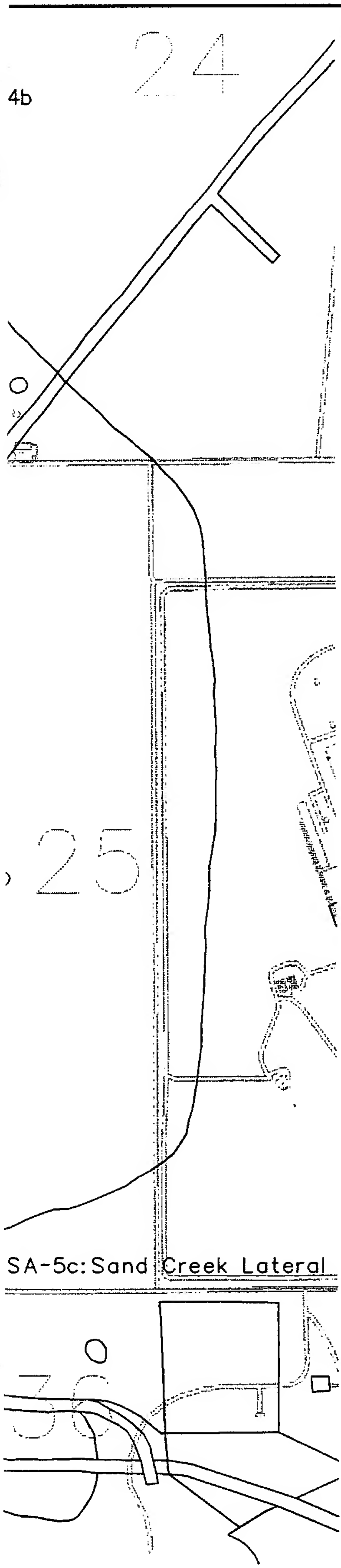
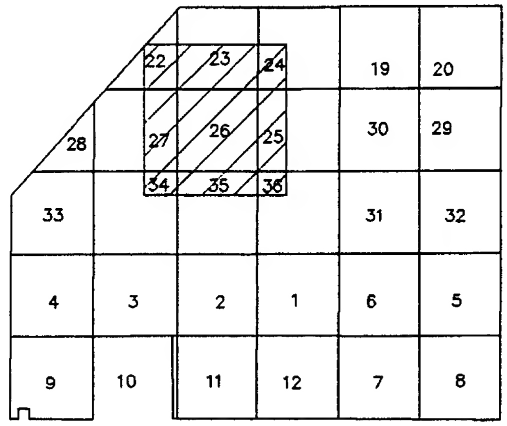




ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Biota Exceedance Area

Human Health Exceedance Area

Site Boundary

Buildings and Roads

26 Section Number

500 0 500 1000 FEET

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for Rocky Mountain Arsenal

FIGURE 12.1-1

Exceedance Areas
Secondary Basins Subgroup

Rocky Mountain Arsenal.
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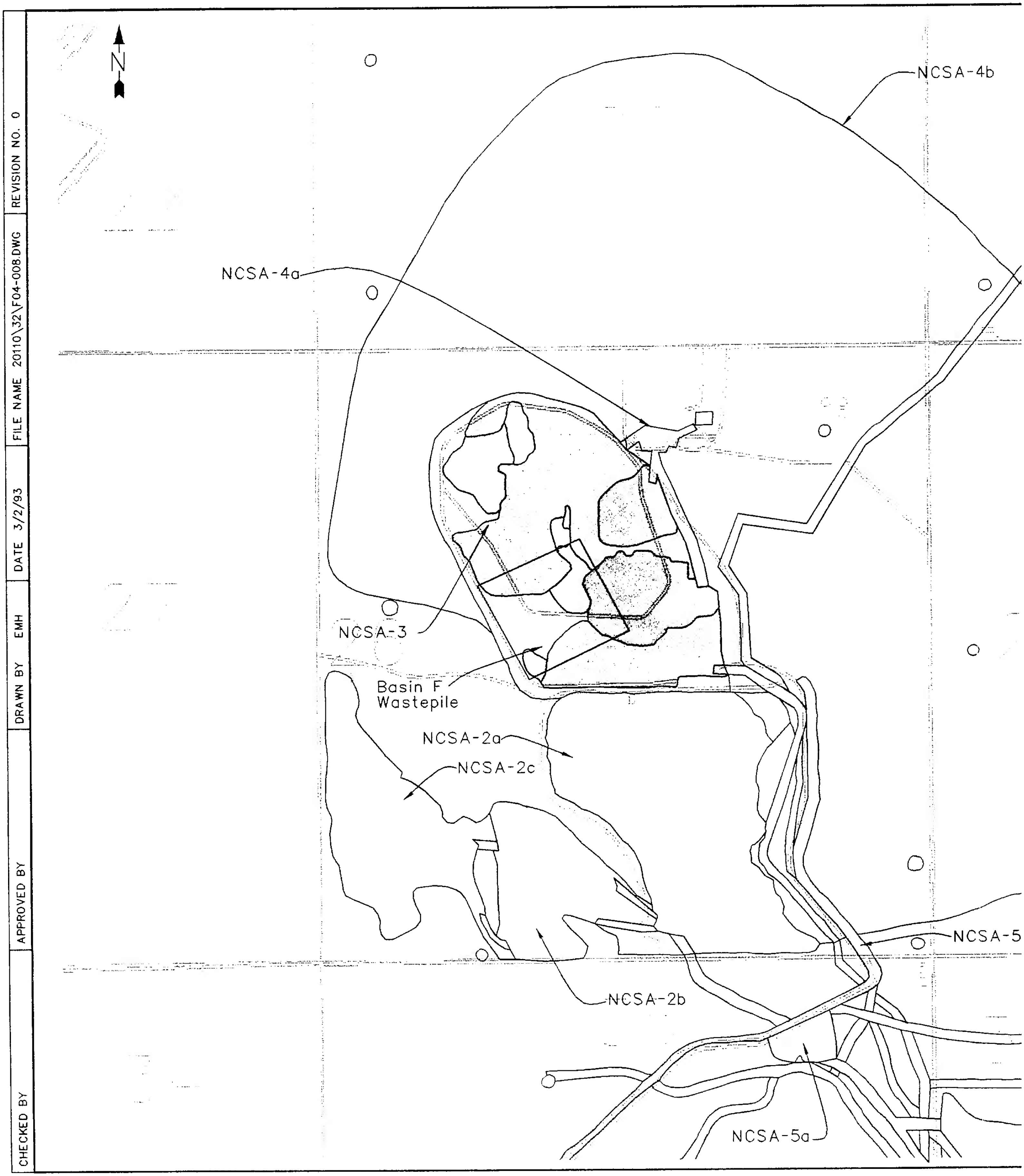
N
NCSA-4b
NCSA-4a
NCSA-3
Basin F
Wastepile
NCSA-2a
NCSA-2c
NCSA-2b
NCSA-5
NCSA-5a
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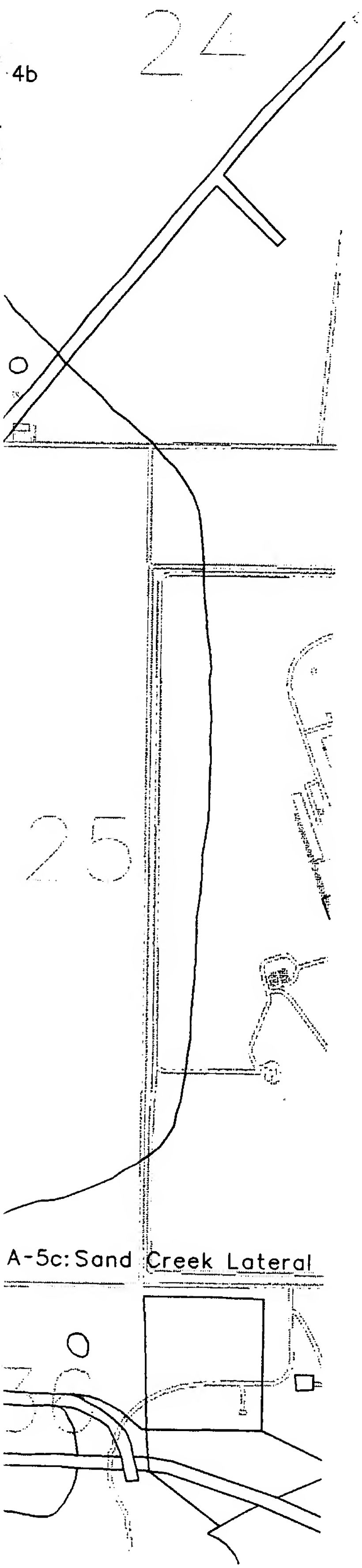
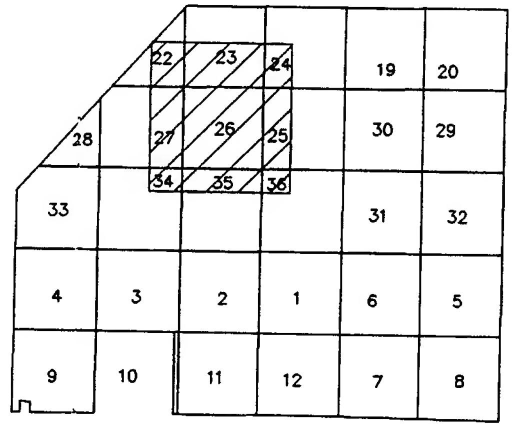


ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

- Biota Exceedance Area
- Human Health Exceedance Area
- Principal Threat Exceedance Area
- Site Boundary
- Buildings and Roads
- 26 Section Number

500 0 500 1000 FEET

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U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE 12.4-1

Exceedance Areas
Former Basin F Subgroup

Rocky Mountain Arsenal.
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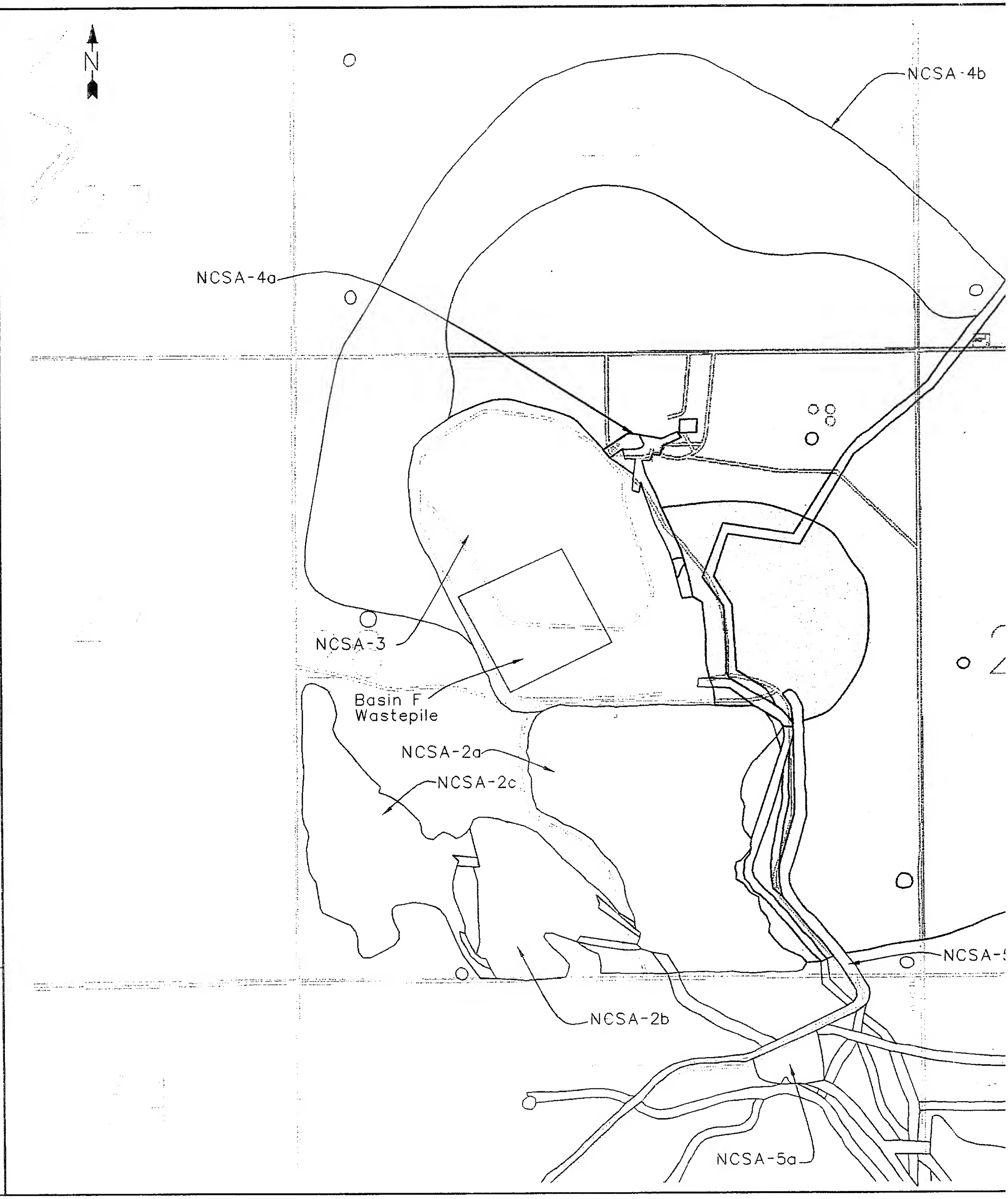

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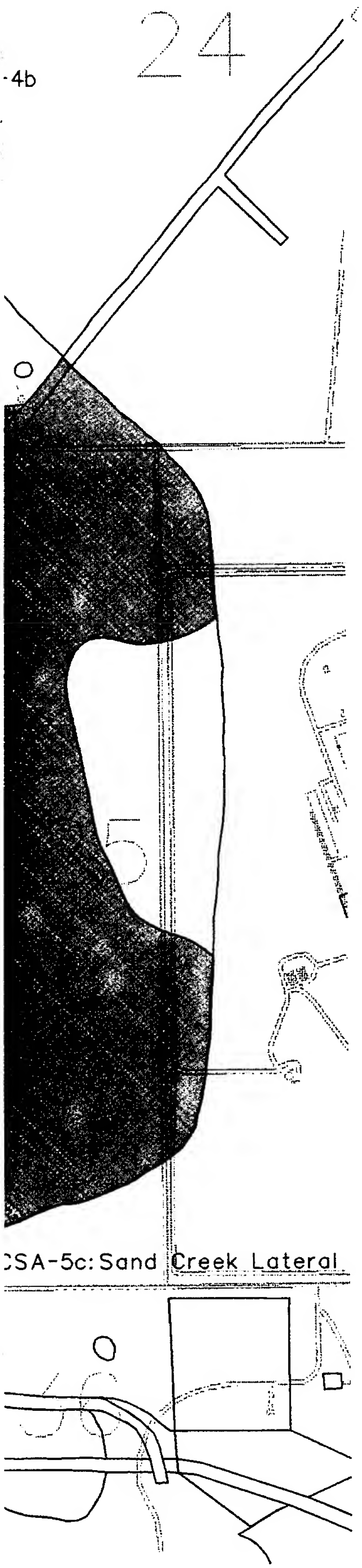
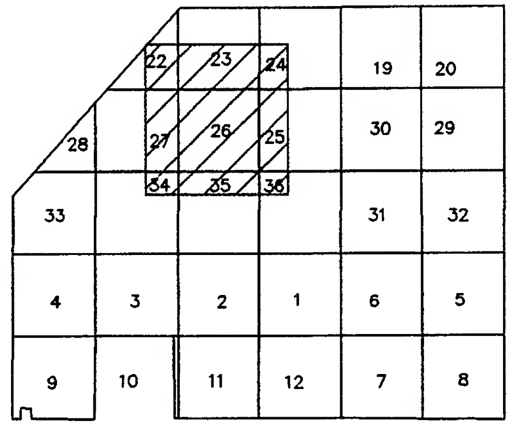


ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Biota Exceedance Area

Human Health Exceedance Area

Site Boundary

Buildings and Roads

26 Section Number

500 0 500 1000 FEET

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for Rocky Mountain Arsenal

FIGURE 12.7-1

Exceedance Areas
Basin F Exterior Subgroup

Rocky Mountain Arsenal.
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12.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE SECONDARY BASINS MEDIUM GROUP

The Secondary Basins Medium Group consists of six exceedance sites including three inactive liquid disposal basins (Basins B, C, and D), one former liquid disposal basin (Basin F), and two sites adjacent to Former Basin F. These six sites are grouped together by site type and contamination pattern to form three subgroups: Secondary Basins, Former Basin F, and Basin F Exterior Subgroup. Figure 12.0-1 shows the locations of the subgroups within the Secondary Basins Medium Group and their related sites.

The primary Human Health and Biota COCs present in this medium group are OCPs, although CLC2A and VOCs are also present at concentrations above the Human Health SEC. Principal threat areas exist at some of the sites due to elevated concentrations of organic contaminants. Portions of this medium group contain mercury and arsenic at levels exceeding the Biota SEC only. Sites within this medium group are also sources of groundwater contamination. Table 12.0-1 presents the characteristics of each subgroup, including exceedance volumes and COCs. Appendix A details volume and area calculations for the subgroup.

In the DSA, alternatives were developed and screened based on the general characteristics of the medium group. In the DAA, however, the retained alternatives do not necessarily apply to each subgroup. The characteristics of the three subgroups—including contaminant types and concentrations, site configuration, and depth of contamination—were evaluated to determine the subset of applicable subgroup alternatives from the range of alternatives retained in the DSA. In some cases, the alternatives were modified to account for the treatment of principal threat areas in a subgroup.

The following sections present the characteristics of each subgroup, an evaluation of the retained alternatives for each subgroup against the DAA criteria listed in the NCP (EPA 1990), and the selection of a preferred alternative based on a comparative analysis of the alternatives. The preferred alternative for each subgroup is as follows:

- Secondary Basins: Alternative 6g—Excavation and consolidation of human health and biota exceedance areas within Basin A for capping.

- Former Basin F: Alternative 6c—Treatment of principal threat areas by direct thermal desorption and augmentation of existing cap with additional low permeability soil cap

- Basin F Exterior: Alternative 6g—Consolidation of human health exceedance areas within Basin A prior to capping, and in situ treatment of biota exceedances in shallow soil by landfarm/agricultural practice.

12.1 SECONDARY BASINS SUBGROUP CHARACTERISTICS

The Secondary Basins Subgroup is composed of sites NCSA-2a (Basin C), NCSA-2b (Basin D), and NCSA-5a (Basin B) (Figure 12.0-1). These basins contain soils contaminated by infiltrating wastewater that flowed through ditches from Basin A. They are also expected to contain somewhat elevated levels of salts resulting from the storage of wastewater with high chloride content. Basin E has no human health or biota exceedances since fluoroacetic acid is not a COC, so this site is no longer included in this subgroup.

Table 12.1-1 provides a summary of contaminants, exceedance volume concentrations, and corresponding exceedance values. The Human Health SEC is exceeded by maximum concentrations of OCPs at depths ranging from 0 to 10 ft below ground surface. Fewer than 2 percent of the samples for any OCP exceed the Human Health SEC (Table 12.1-2). The Biota SEC was exceeded for OCPs, arsenic, and mercury at depths up to 10 ft below ground surface; however, most of these contaminants were detected in the 0- to 1-ft depth interval. Figure 12.1-1 shows the physical configurations of the sites and the distribution of exceedance areas, and Table 12.0-1 lists the exceedance areas and volumes.

Sites in the Secondary Basins Subgroup have been identified as historical sources of groundwater contamination. Basin C has been further identified as a groundwater plume source. This plume occurs in the unconfined aquifer and extends from the vicinity of Basins C and F in Section 26, northeast through Sections 23 and 24 toward the North Boundary Containment System (NBCS) where the groundwater is intercepted and treated. The southern limit of the plume appears to be

separated from the Basin A Neck Plume by a bedrock ridge. A portion of the Basin A Neck Plume may have historically migrated and/or may currently be moving through the bedrock into the Basins C and F Plume area at the south end of Basin C. Groundwater alternatives that address improved performance for the NBCS or the addition of individual plume group remediation systems are being evaluated. Coordination of alternatives developed for the soils medium with those developed for the water medium is limited to source containment or removal as it is unlikely that the NBCS could be shut down following the remediation of this subgroup due to the mass loading already in the aquifer.

Habitat of sites within this subgroup range in value from poor to high. In general, the habitat is considered poor, but Basin B is located on the edge of a prairie dog colony area that is considered a high-quality habitat. For most of the alternatives developed for this subgroup, the areas disturbed during remedial actions are revegetated with native grasses in accordance with a refuge management plan. In most instances, the overall habitat value is improved, offsetting the short-term loss of habitat resulting from remedial actions. The institutional controls alternative includes provisions for modifying the habitat by seeding lower-quality grasses to reduce the desirability of the area for biota. In this instance, the habitat quality is lowered and the available habitat area at RMA is reduced.

12.2 SECONDARY BASINS SUBGROUP EVALUATION OF ALTERNATIVES

The alternatives for the Secondary Basins Subgroup vary in approach from no action to treatment. The nomenclature of the alternatives retained from the DSA for this subgroup was modified primarily to indicate clearly that solidification of inorganics is not required following organics treatment (Alternative 13a versus Alternative 13). One alternative (Alternative 6g) was added to evaluate the consolidation of contaminated soils into Basin A for containment. In addition, the containment alternative (Alternative 6) was modified to delete proposed slurry walls because of the proximity of the Basin F Groundwater IRA system and the NBCS. Alternative 9a: Direct Soil Washing; Direct Thermal Desorption was removed from consideration. This alternative was retained in the DSA solely for its ability to treat FC2A. Since FC2A is no longer considered a

COC, the alternative is no longer applicable to this subgroup. The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA. The alternatives for this subgroup consist of an alternative to address human health exceedances (which is listed first) and an alternative for areas with biota exceedances (the "B" alternative).

12.2.1 Alternative 1/B1: No Additional Action

Alternative 1: No Additional Action (Provisions of FFA), along with Alternative B1: No Additional Action (Provisions of FFA), applies to all 430,000 SY of exceedance area in the Secondary Basins Subgroup. The 300,000 BCY of human health and biota exceedance volume remains in place, and no action is taken to reduce human or biota exposure to COCs or to reduce potential groundwater contamination from sites in this group. Long-term monitoring of untreated soils is conducted (an average of 50 samples per year) and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants in exceedance areas.

Table 12.2-1 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative does not achieve Human Health and Biota RAOs as untreated soils remain in place without the implementation of controls. Natural attenuation of this contamination is ongoing, but the estimated time frame to achieve PRGs is more than 30 years. The residual risk is low due to the low levels of contamination in the soil, but the potential continual impacts on groundwater quality are not addressed. The predominantly poor-quality habitat at the sites is not changed. The total estimated present worth cost of this alternative is $3,100,000. Table B4.3-1 details the costing for this alternative.

12.2.2 Alternative 2/B2: Access Restrictions

Alternative 2: Access Restrictions (Modifications to FFA), along with Alternative B2: Biota Management (Exclusion, Habitat Modification), applies to the total exceedance area of 430,000 SY in the Secondary Basins Subgroup. The biota and human health exceedance volume of

300,000 BCY remains in place, but exposure pathways are interrupted. Human and biota access to the sites are restricted by the installation of 20,000 ft of perimeter chain-link fencing. In addition, biota exclusion is promoted by revegetating exceedance areas with grasses unappealing to biota to reduce the value of the habitat. Revegetation of 430,000 SY is accomplished over a 3-year period. Long-term activities include maintaining fences, mowing and spot herbiciding revegetated areas, and monitoring for erosion and vegetation damage. The importance of maintaining and respecting access restrictions to prevent inadvertent exposure is presented in an ongoing public education program. No actions are taken to reduce potential groundwater contamination. Exceedance areas are monitored (an average of 50 samples per year) and 5-year site reviews are conducted to review the effectiveness of the alternative and to assess natural attenuation/degradation and potential migration of contaminants.

Table 12.2-2 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves RAOs by interrupting exposure pathways, so there is a low residual risk of exposure, but the potential migration of contaminants to groundwater is not reduced. The time frame required to achieve RAOs is 3 years due to the time involved in modifying the habitat through revegetation. Long-term maintenance is required to ensure the effectiveness of the access controls. Human health and biota exceedances remain in place, although natural attenuation of contamination is ongoing. The 430,000 SY of habitat present in this subgroup is eliminated for biota. The total estimated present worth cost of this alternative is $4,100,000. Table B4.3-2 details the costing for this alternative.

12.2.3 Alternative 6/B5: Caps/Covers

Alternative 6: Caps/Covers (Clay/Soil Cap), in combination with Alternative B5: Caps/Covers (Clay/Soil Cap), involves the installation of a 430,000-SY low-permeability soil cap to contain the human health and biota exceedance areas. (Section 4.6.8 discusses low-permeability soil caps in detail.) The subgrade is compacted before any cover materials are installed and is crowned with common fill and soils to achieve the design grades of 1.5 to 3 percent. Approximately 140,000 BCY of soils are needed as grading fill. Most of the required fill can be supplied by

the 100,000 BCY of soils comprising the dikes that surround these sites; these dikes need to be removed to prevent the ponding of water on the capped area. An on-post borrow area supplies the remaining 38,000 BCY of grading fill and most of the materials for the cap. The cap consists of a 3-ft layer of compacted low-permeability soil, a 1-ft biota barrier of cobbles, and a 4-ft soil/vegetation layer that includes 6 inches of topsoil. Topsoil is obtained off post. The cap is revegetated and burrowing animals are excluded to prevent damage to the containment system. The borrow area is recontoured and revegetated. Maintenance activities, such as grass mowing and replacement of eroded cap materials, ensures the continued integrity of the soil cover. Five-year site reviews are conducted to review the effectiveness of the alternative and to assess potential migration of contaminants.

Table 12.2-3 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs through containment. The cap reduces the potential for migration of contaminants to groundwater by reducing infiltration and interrupts exposure pathways for humans and biota. The capping operations take approximately 1 year to complete, and habitat is improved at the site after remediation, although burrowing animals are excluded from the area. Long-term maintenance is required over 3 separate areas corresponding to the three sites to ensure the integrity of the cap. The total estimated present worth cost of this alternative is $34,000,000. Table B4.3-6 details the costing for this alternative.

12.2.4 Alternative 6g/B5a: Caps/Covers with Consolidation

Alternative 6g: Caps/Covers (Clay/Soil Cap) with Consolidation, along with Alternative B5a: Caps/Covers (Clay/Soil Cap) with Consolidation, addresses human health and biota exceedance volumes by excavation of 300,000 BCY of contaminated soils, transportation of the soils to Basin A, consolidation as grading fill over the more highly contaminated soil present in the basin, and containment with a clay/soil cap. (Section 4.6.8 discusses clay/soil caps in detail.) The selection of this alternative is predicated on the selection of Alternative 6f for Basin A. As discussed in Section 10.2.4, the containment of Basin A requires a large amount of grading fill to achieve design grades. Consolidation removes contamination from the Secondary Basins Subgroup and

helps meet the need for grading fill in Basin A. The site excavations are backfilled with clean borrow material from an on-post borrow area and covered with topsoil obtained off post. Site remediation is completed by revegetation. The borrow area is also recontoured and revegetated. No maintenance activities are required at the site because all of the exceedance soils are removed. Long-term maintenance at Basin A ensures the integrity of the low-permeability soil cap.

Table 12.2-4 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs through consolidation and containment of exceedance soils at Basin A. The potential for migration of contaminants to surface water and groundwater is reduced and exposure pathways are interrupted. Habitat is improved at the site after remediation and is restored at the borrow area. The consolidation and backfilling operations take 1 year to complete based on the large volumes of soils to be transported. Under this alternative, no maintenance activities are required at sites within this subgroup. The total estimated present worth cost of this alternative is $12,000,000. Table B4.3-6g details the costing for this alternative.

12.2.5 Alternative 13a/B6: Direct Thermal Desorption

Alternative 13a: Direct Thermal Desorption (Direct Heating), combined with Alternative B6: Direct Thermal Desorption (Direct Heating), treats 300,000 BCY of contaminated soils from the Secondary Basins Subgroup. These soils have human health or biota exceedances of OCPs, arsenic, and mercury.

The total exceedance volume is excavated and transported to the centralized thermal desorption facility for treatment. (Section 4.6.24 discusses the details of thermal desorption.) The facility takes approximately 1 year to build and an additional year for testing before soils are processed. For dry soils from this subgroup, the thermal desorber has a processing rate of approximately 2,000 BCY/day and operates with a soil discharge temperature of 300°C and a residence time of 30 minutes. When operating under these conditions, the thermal desorber volatilizes all of the

mercury and some of the arsenic present in the contaminated soils so that solidification of the treated soil is not required. (Section 4.6.24 discusses emission controls for off gases from thermal desorption.) Approximately 1 percent of the total soils feed (3,000 BCY) is recovered as particulates from scrubber blowdown and is disposed into the on-post hazardous waste landfill. The treated soils are returned to the site excavations and used as backfill. Since thermal desorption destroys the natural organic content of the soils, topsoil is placed on the backfilled area of 430,000 SY, and the area is revegetated with native grasses.

Table 12.2-5 details the evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves both Human Health and Biota RAOs since all contaminated soils are treated to remove or destroy the exceedance COCs. The residual risk achieves PRGs, and the migration of contaminants to groundwater is eliminated through the thermal treatment of the exceedance soils. The habitat is improved at the sites following revegetation, offsetting the temporary disruption that occurs during excavation and treatment. The thermal desorption of 300,000 BCY of contaminated soils requires approximately 1 year and construction and testing of the facility requires 2 years, for a total of 3 years. The total estimated present worth cost of this alternative is $41,000,000. Table B4.3-13a details the costing for this alternative.

12.2.6 Alternative 19a/B11a: In Situ Thermal Treatment

For the Secondary Basins Subgroup, Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating), combined with Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating) treats 300,000 BCY of contaminated soils through in situ RF heating. (Section 4.6.30 discusses RF heating in detail.) RF heating mobilizes the organic contaminants by raising the temperature of the soils to more than 250°C. The mobilized contaminants are collected and treated in the off-gas treatment system as described in Section 4.6.30. Two types of RF heating units, deep and shallow, are used for treatment of the human health organic exceedance volume of 6,800 BCY and the biota exceedance volume of 290,000 BCY. The deep unit treats a 100-ft-long, 48-ft-wide, 10-ft-deep block of soil, while the shallow unit treats a 100-ft-long, 36-ft-wide, 5-ft-deep block. The moisture content of soil in the Secondary Basins Subgroup is approximately 10

percent. Therefore, the RF treatment rate, which varies with moisture content, is 90 and 80 BCY/day for the deep and shallow units, respectively. The liquid sidestream from in situ heating, along with the scrubber effluent, which contains predominantly salts, is transported to the thermal desorption facility for treatment in the evaporator. A 6-inch layer of topsoil, obtained off post, is placed over the treated human health organic and biota area of 430,000 SY to provide a growth medium for vegetation. The treated areas are then revegetated with native grasses.

Table 12.2-6 details the evaluation of the alternative against the EPA criteria for the DAA. RF heating can theoretically achieve Human Health and Biota RAOs with low residual risk since all OCPs and some fraction of the volatile metals can be driven from the soil by this form of in situ thermal desorption. However, the pilot-scale test of the RF heating technology at RMA failed to confirm the temperature distribution and OCP removal required for confident treatment of soils to achieve PRGs. For this subgroup, however, the DRE of 97–99.9 percent achieved by this technology will reduce contaminant levels to meet both Human Health and Biota PRGs. Migration of contaminants to groundwater is reduced by treatment of the contaminated soils. The treated areas are revegetated to improve habitat. The implementability of in situ RF heating is questionable since there is no commercial source for the equipment and the technique is as yet unproven at full scale. The treatment of 300,000 BCY of contaminated soils is feasible within 6 years. The total estimated present worth cost of this alternative is $130,000,000. Table B4.3-19a details the costing for this alternative.

12.3 SECONDARY BASINS SUBGROUP SELECTION OF PREFERRED ALTERNATIVE

The Secondary Basins Subgroup contains approximately 300,000 BCY of soils predominantly contaminated with OCPs, although arsenic and mercury also exceed the Biota SEC in portions of the subgroup. This contamination resulted from infiltrating wastewater that flowed through ditches from Basin A, so the contamination patterns are relatively homogeneous compared to the heterogenous contamination in the disposal trench and spill sites. Dieldrin and Endrin have the most samples exceeding the Biota SEC (approximately 30 percent of the samples taken), and, in general, fewer than 2 percent of the OCP samples exceed the Human Health SEC (Table 12.1-2).

The sites in this subgroup represent a relatively low risk to human health as the average concentrations of individual OCPs in the human health exceedance volume are about equal to the Human Health SEC (Table 12.1-1). Average OCP concentrations in the biota exceedance volume are generally only slightly above the Biota SEC.

In general, the habitat present at sites in this subgroup is poor, although Basin B is located on the edge of a prairie dog colony area that is considered to be a high-quality habitat. Remedial actions that disturb the existing habitat include revegetation following remediation. In most instances, the overall habitat value is improved, offsetting the short-term loss of habitat during remedial actions.

Alternatives that involve excavation of human health exceedances require protection for site workers during remedial activities, but the short-term risk to workers is minimal with the use of proper personal protective equipment (PPE). The degree of contamination in sites in this subgroup does not necessitate special measures for odor control and community protection during remediation.

In summary, the Secondary Basins Subgroup contains low levels of contamination that exceed the Biota SEC and, in limited areas, that also exceed the Human Health SEC. Habitat impacts and community protection are not significant factors for consideration in selecting the preferred alternative for this subgroup.

Alternative 1: No Additional Action does not achieve Human Health or Biota RAOs as contaminated and uncontained soils remain without controls being initiated, so the alternative is eliminated from further consideration as the preferred alternative. The remaining six alternatives achieve RAOs; and are protective of human health and the environment and comply with action- and location-specific ARARs, thus satisfying both of the threshold criteria. The alternatives are distinguished by the five balancing criteria (Table 12.2-1 through 12.2-7).

Of the protective alternatives, Alternative 2: Access Restrictions has the lowest cost ($4,100,000), but is the least protective since contaminants remain in place untreated and uncontained. In addition, the alternative results in the removal of 430,000 SY for use as habitat. Alternative 2 requires 3 years in order to effectively modify the habitat and protect biota. Of the two treatment alternatives, Alternative 19a: In Situ Thermal Treatment achieves Human Health and Biota RAOs, but is unproven for full-scale operation and has the highest cost ($130,000,000). The other treatment alternative, Alternative 13a: Direct Thermal Desorption ($41,000,000), costs more than the two containment alternatives.

Alternative 6/B5: Caps/Covers and Alternative 6g: Caps/Covers with Consolidation exhibit similar levels of effectiveness. They both achieve RAOs and reduce exposure pathways and groundwater contamination through engineering controls. Both alternatives improve habitat, but Alternative 6: Caps/Covers excludes burrowing animals as a result of the installation of a biota barrier layer and requires long-term monitoring and maintenance of a 430,000-SY area. Alternative 6: Caps/Covers, also costs considerably more that Alternative 6g: Caps/Covers with Consolidation ($34,000,000 and $12,000,000, respectively).

The preferred alternative for the Secondary Basins Subgroup is Alternative 6g: Caps/Covers with Consolidation. This alternative costs less than Alternative 6/B5: Caps/Covers, minimizes monitoring and maintenance costs, and reduces the number of distinct containment sites by consolidating contaminated material under the Basin A cap. The selection of this alternative is consistent with NCP guidance on containment for lower levels of contamination. The groundwater control system evaluated for the Basins C and F Plume is located north of the former Basin F. As such, the selection of this alternative does not impact the evaluation of groundwater alternatives.

12.4 FORMER BASIN F SUBGROUP CHARACTERISTICS

The Former Basin F Subgroup is composed of site NCSA-3 (Former Basin F) (Figure 12.0-1). In 1989, the Basin F IRA was conducted to remove Basin F liquids and sludges, the asphalt liner

of the basin, and highly contaminated soils from beneath the liner. As discussed in Section 11.0, these materials were placed in the Basin F Wastepile. The existing site contains contaminated soils that were not removed in the IRA. A soil cover was placed over the former Basin F following the construction of the wastepile. The 2- to 5-ft-thick soil cover has an average thickness of 3 ft. The soil cover was revegetated at the conclusion of the IRA.

The Former Basin F Subgroup contains soils contaminated by wastewater that infiltrated during Basin F operations. Table 12.4-1 provides a summary of contaminants, exceedance volume concentrations, and exceedance values, and Table 12.4-2 summarizes the frequency of detections for samples taken in the subgroup. The Human Health SEC are exceeded by average and maximum concentrations of OCPs and CLC2A in 700,000 BCY of human health exceedance volume. The maximum concentrations of aldrin, dieldrin, and isodrin (2,900 ppm, 1,400 ppm, and 7,500 ppm, respectively) also exceed the principal threat criteria (10^{-3} excess cancer risk, HI of 1,000) in approximately 220,000 BCY. Less than 4 percent of the samples for these OCPs exceed the principal threat criteria. These Human Health COCs were found from 0 to 10 ft below ground, but were primarily detected in the 0- to 5-ft depth interval. The Biota SEC are exceeded for OCPs and arsenic in 89,000 BCY of soil. These Biota COCs were found from 0 to 10 ft below ground surface, but the majority were detected from 0 to 3 ft below ground. Figure 12.4-1 shows the distribution of the exceedance areas, including principal threat areas, for this subgroup, and Table 12.0-1 lists the exceedance volumes and areas.

Site NCSA-3 has been identified as a source of groundwater contamination. Although the Basin F IRA has removed the majority of the source for groundwater contamination, high concentrations of COCs are still present above the water table at the site. As discussed in Section 12.1, the Basins C and F Plume occurs in the unconfined aquifer and extends from the vicinity of Basins C and F in Section 26 to the northeast toward the NBCS. Contaminated groundwater north of the former Basin F is intercepted by the Basin F Groundwater IRA extraction system and treated at the Basin A Neck IRA treatment system. Groundwater alternatives are being evaluated that address improved performance for the existing groundwater

treatment systems or the addition of individual plume group remediation systems. Coordination of alternatives developed for the soils medium with those developed for the water medium is limited to source containment or removal as it is unlikely that the remediation of the former Basin F would result in the shutdown of either system due to the contaminant mass already present in the aquifer.

The Former Basin F Subgroup provides poor-quality habitat based on the vegetation types encountered at the site. For most of the alternatives for this subgroup, the areas disturbed during remedial actions are revegetated with native grasses in accordance with a refuge management plan. In most instances, the overall habitat is improved, which should offset the short-term loss of habitat resulting from remedial actions. The institutional controls alternative includes provisions for modifying the habitat by seeding lower-quality grasses to reduce the desirability of the area for biota. In this instance, the habitat quality is lowered and the available habitat area on RMA is reduced by 420,000 SY.

12.5 FORMER BASIN F SUBGROUP EVALUATION OF ALTERNATIVES

The alternatives for the Former Basin F Subgroup vary in approach from no action to treatment. The alternatives retained from the DSA for this subgroup were modified to include treatment of principal threats areas and the nomenclature changed to indicate clearly that solidification of inorganics is not required following organics treatment (Alternative 13a versus Alternative 13). In addition, the containment alternative (Alternative 6c) was modified to delete proposed slurry walls because of the presence of the nearby Basin F Groundwater IRA treatment system and the proximity of the NBCS. Alternative 9a: Direct Soil Washing; Direct Thermal Desorption was removed from consideration as the preferred alternative. This alternative was retained in the DSA solely for its ability to treat FC2A. Since FC2A is no longer considered a COC, the alternative is no longer applicable to this subgroup. The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA. The alternatives for this subgroup consist of an alternative to address human health

exceedances (which is listed first) and an alternative for areas with biota exceedances (the "B" alternative).

12.5.1 Alternative 1/B1: No Additional Action

Alternative 1: No Additional Action (Provisions of FFA), along with Alternative B1: No Additional Action (Provisions of FFA), applies to all 420,000 SY of exceedance area in the Former Basin F Subgroup. The 790,000 BCY of human health, principal threat, and biota exceedance volume remain in place without implementation of controls. The existing cap interrupts exposure pathways, but no additional action is taken to reduce human or biota exposure to COCs or to reduce potential groundwater contamination from this site. Long-term activities include maintenance of the existing cap and monitoring of untreated soils (an average of 43 samples per year). Five-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Table 12.5-1 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative partially achieves RAOs by interrupting human health exposure pathways, although it does not provide adequate controls for biota. The existing soil cap is protective of human health exposure, so the residual risk is low. Natural attenuation of contamination is ongoing, but the estimated time frame to achieve PRGs is more than 30 years. The poor-quality habitat at the site is not changed. The total estimated present worth cost of this alternative is $7,200,000. Table B4.4-1 details the costing for this alternative.

12.5.2 Alternative 1a/B1: Direct Thermal Desorption of Principal Threat Volume; No Additional Action

Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA), along with Alternative B1: No Additional Action (Provisions of FFA), involves treatment of the principal threat exceedances in the Former Basin F Subgroup. The existing soil cap, amounting to 110,000 BCY, is excavated from these areas as overburden and stockpiled nearby. The principal threat volume of 220,000 BCY is excavated

and hauled to a centralized facility for thermal desorption. Due to the potential for odor problems from the soils, the excavation of overburden and principal threat soil is conducted using temporary soil cover layers or plastic liners so that minimal area is uncovered and exposed at any one time. The thermal desorber requires 1 year to build and another year for testing before soils can be processed. (Section 4.6.24 discusses the details of thermal desorption.) The thermal desorber processes dry soil from this subgroup at a rate of approximately 2,000 BCY/day and has a soils residence time of 30 minutes, achieving a soils discharge temperature of 300°C. (Section 4.6.24 discusses emission controls for off gases from thermal desorption.) Particulates from quench blowdown amount to approximately 1 percent of the total solids feed. This particulate volume of 2,200 BCY is disposed in the centralized on-post landfill. The treated soil is returned and backfilled into former Basin F, and the stockpiled overburden is backfilled to cover the treated soil. The disturbed area of 110,000 SY is revegetated with native grasses to restore the habitat.

The remaining human health and biota exceedance areas in the Former Basin F Subgroup fall under the no additional action part of this alternative. An exceedance volume of 570,000 BCY remains in place and no controls are implemented. The existing soil cap interrupts exposure pathways, but no additional action is taken in these areas to reduce human or biota exposure to COCs or to reduce potential groundwater contamination from this site. Some residual risk remains for both human health and biota based on the average concentrations of COCs. Long-term activities include maintenance of the existing cap and monitoring of untreated soils (an average of 43 samples per year). Five-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Table 12.5-2 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. RAOs are partially achieved through the treatment of principal threats and interruption of human health exposure pathways, but adequate controls are not initiated to protect biota. Natural attenuation is ongoing, but the estimated time frame to achieve PRGs is more than 30 years. Treating principal threat areas and maintaining the existing soil cap protects human health

exposure and results in low residual risk. Migration of contaminants to groundwater is reduced, but this alternative does not prevent exposures to biota, nor does it eliminate groundwater contamination. Habitat is restored in the principal threat area after treatment, but the poor-quality habitat in the remainder of the site is not improved. The time frame for completion of the alternative is 3 years due to the time required for construction and testing of the central thermal desorption facility. The total estimated present worth cost of this alternative is $35,000,000. Table B4.4-1a details the costing for this alternative.

12.5.3 Alternative 2a/B2: Direct Thermal Desorption of Principal Threat Volume; Access Restrictions

Alternative 2a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modification to FFA), combined with Alternative B2: Biota Management (Exclusion, Habitat Modification), involves treatment by thermal desorption of the principal threat volume found in the Former Basin F Subgroup and the initiation of access restrictions and habitat modifications for the remaining areas. The principal threat volume of 220,000 BCY is excavated and hauled to a centralized facility for thermal desorption. Prior to excavating the contaminated soils, 110,000 BCY of the existing soil cover is excavated as overburden and stockpiled nearby. Daily soil covers or plastic liners are placed on each excavated area to minimize the odors and volatile emissions generated during excavation operations. The thermal desorber takes 1 year to build and requires another year for testing before soils can be processed. (Section 4.6.24 discusses the details of thermal desorption.) The dry soil is processed through the desorber at a rate of approximately 2,000 BCY/day. After a residence time of 30 minutes, the soils are discharged at a temperature of 300°C. (Section 4.6.24 discusses emission controls for off gases from thermal desorption.) Particulates from scrubber blowdown, approximately 1 percent of the total feed (2,200 BCY), are disposed in the on-post hazardous waste landfill. The treated soil is returned and backfilled into former Basin F and the stockpiled overburden is backfilled to cover the treated soil. Revegetation is accomplished with the remaining area of the former basin as discussed below.

The remaining human health and biota exceedance areas in the Former Basin F Subgroup are addressed by access restrictions. An exceedance volume of 570,000 BCY remains in place, but exposure pathways are interrupted through the existing cap and the initiation of access controls. Human and biota access to the site are restricted by the installation of 8,100 ft of perimeter chain-link fence with warning signs. Some residual risk is still present for human health and biota based on the average concentrations of COCs. Over a 3-year period, 420,000 SY (which includes the area thermally desorbed) are revegetated with lower-quality grasses to reduce the value of the habitat for wildlife and promote biota exclusion from the site. The habitat modifications and fencing require long-term maintenance to ensure the effectiveness of these controls. To prevent inadvertent exposures, an ongoing public education program is implemented to illustrate the importance of respecting access restrictions to the site. Other long-term activities include maintenance of the existing cap and monitoring of exceedance areas (an average of 43 samples per year). Five-year site reviews are conducted to review the effectiveness of the alternative and to assess natural attenuation/degradation and potential migration of contaminants.

Table 12.5-3 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. RAOs are achieved for human health and biota exposure. Treatment of principal threat areas, access controls, and the existing soil cap interrupt exposure pathways and result in a low residual risk at the site. Groundwater contamination is reduced through treatment of principal threat areas, but is not prevented by this alternative. A total of 420,000 SY of poor-quality habitat at the site is eliminated. The overall time frame of 3 years for achieving RAOs includes the 2 years required for construction and testing of the central thermal desorption facility. The total estimated present worth cost of this alternative is $36,000,000. Table B4.4-2a details the costing for this alternative.

12.5.4 Alternative 6c/B5b: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers with Modifications to Existing System

Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Modifications to Existing System, along with Alternative B5b:

Caps/Covers (Clay/Soil Cap) with Modifications to Existing System, involves the thermal treatment of 220,000 BCY and the containment of 420,000 SY of human health and biota exceedance area. Approximately 110,000 BCY of the interim cover is excavated from principal threat areas as overburden and stockpiled nearby. The 220,000 BCY of soils that exceed the principal threat criteria in this subgroup are excavated and transported to the thermal desorber for treatment. Daily soil covers or plastic liners are placed on each excavated area to minimize the odors and volatile emissions generated during excavation operations. The thermal desorber takes 1 year to build and requires another year for testing before soils can be processed. (Section 4.6.24 discusses details of thermal desorption.) The dry soils from this subgroup are processed through the desorber at a rate of approximately 2,000 BCY/day and require a residence time of 30 minutes to achieve a soils discharge temperature of 300°C. (Section 4.6.24 discusses emission controls for the treatment of off gases from thermal desorption.) Approximately 1 percent of the total soils feed (2,200 BCY) is recovered as particulates from scrubber blowdown and is disposed in the on-post landfill. The thermally desorbed soils are backfilled in the site and covered with the stockpiled cover materials.

The entire human health and biota exceedance area is then covered with a modified low-permeability soil cap over the existing interim soil cover. The uppermost 2 ft of the existing soil cover is removed, stockpiled, and incorporated into the soil/vegetation layer of the augmented clay/soil cap. The subsurface is compacted and regraded to minimize variations in the subgrade. The modified cap consists of a 2-ft layer of compacted low-permeability soil, a 1-ft layer cobble biota barrier, and a 4-ft soil/vegetation layer that includes 6 inches of topsoil. Most of the fill materials are excavated from an on-post borrow area, but the topsoil and cobbles are obtained off post. The cap is revegetated, but burrowing animals are excluded by the biota barrier to prevent damage to the containment system. The borrow area is also recontoured and revegetated to restore the habitat. Long-term activities include maintaining the revegetated area and repairing erosion damage. Five-year site reviews are conducted to review the effectiveness of the alternative.

Table 12.5-4 present the detailed evaluation of this alternative against the EPA criteria for the DAA. The alternative achieves Human Health and Biota RAOs through treatment of principal threat volumes and containment of the remaining exceedance soils. The augmented cap eliminates exposure pathways so long as the cap does not degrade or leak. The migration of contaminants to groundwater is reduced through treatment of the principal threat area and containment. Biota disturbance during remedial actions is minimal due to the existing poor-quality habitat. Residual risk is low. The habitat is improved through revegetation after remediation, but burrowing animals are excluded from the capped area. Including the 2 years required to build and test the thermal desorber, the implementation of this alternative requires a total of 3 years. The total estimated present worth cost of this alternative is $58,000,000. Table B4.4-6c details the costing for this alternative.

12.5.5 Alternative 6d/B5b: Caps/Covers with Modifications to Existing System

Alternative 6d: Caps/Covers (Clay/Soil Cap) with Modifications to Existing System, along with Alternative B5b: Caps/Covers (Clay/Soil Cap) with Modifications to Existing System, addresses the human health and biota exceedance areas by modifying 420,000 SY of the existing soil cover with a modified low-permeability soil cap. The uppermost 2 ft of the existing soil cover are removed, stockpiled, and incorporated into the soil/vegetation layer. The subsurface is compacted and regraded to minimize variations in the subgrade. The modified cap consists of a 2-ft layer of compacted low-permeability soil, a 1-ft cobble biota barrier, and a 4-ft soil/vegetation layer that includes 6 inches of topsoil. Most of the fill materials are excavated from an on-post borrow area, but the topsoil and cobbles are obtained off post. The cap is revegetated, but burrowing animals are excluded by the biota barrier to prevent damage to the containment system. The borrow area is also recontoured and revegetated to restore the habitat. Long-term activities include maintaining the revegetated area and repairing erosion damage. Five-year site reviews are conducted to review the effectiveness of the alternative.

Table 12.5-5 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. The alternative achieves Human Health and Biota RAOs through containment of the

exceedance soils. The augmented cap eliminates exposure pathways so long as the cap does not degrade or leak. The migration of contaminants to groundwater is reduced through containment. Biota disturbance during remedial actions is minimal due to the existing poor-quality habitat. Residual risk is low. The habitat is improved through revegetation after remediation, but burrowing animals are excluded from the capped area. The implementation of this alternative requires 1 year. The total estimated present worth cost of this alternative is $31,000,000. Table 4.4-6c details the costing for this alternative.

12.5.6 Alternative 13a/B6: Direct Thermal Desorption

For the Former Basin F Subgroup, Alternative 13a: Direct Thermal Desorption (Direct Heating), combined with Alternative B6: Direct Thermal Desorption (Direct Heating), involves the excavation and treatment of 790,000 BCY of human health and biota exceedances that contain primarily OCPs, VOCs, CLC2A, dibromochloropropane (DBCP), and arsenic. The 420,000 BCY of soils from the existing cover is excavated as overburden and set aside prior to excavation and treatment of the contaminated soil. Daily soil covers or plastic liners are placed on each excavated area to minimize the odors and volatile emissions generated during excavation operations. The thermal desorber takes approximately 1 year to build and requires an additional year for testing before soils can be processed. (Section 4.6.24 discusses the details of thermal desorption.) The dry soil from this subgroup is processed through the desorber at a rate of approximately 2,000 BCY/day. The thermal desorber operates with a soil discharge temperature of 300°C and requires a residence time of 30 minutes. When operating under these conditions, the thermal desorber volatilizes all of the mercury and much of the arsenic present in the contaminated soils so that solidification of the treated soil is not anticipated. (Section 4.6.24 discusses the treatment of off gases from thermal desorption.) Approximately 1 percent of the total soils feed (7,900 BCY) is recovered as particulates from scrubber blowdown and is disposed in the on-post hazardous waste landfill. The treated soils are returned to the site excavations as backfill and covered with the stockpiled overburden material. The backfilled areas are revegetated with native grasses to improve habitat.

Table 12.5-6 details the evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves both Human Health and Biota RAOs since all contaminated soils are treated to remove or destroy the exceedance COCs. The residual risk achieves PRGs. The potential for migration of contaminants to groundwater is reduced through the treatment of the exceedance soils. The habitat is improved at the site following treatment and revegetation. Remedial actions for this alternative require 4 years: 2 years for the construction and testing of the thermal desorption facility, and 2 years for thermal desorption of 790,000 BCY of contaminated soils. The total estimated present worth cost of this alternative is $100,000,000. Table B4.4-13a details the costing for this alternative.

12.5.7 Alternative 19a/B11a: In Situ Thermal Treatment

Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating), combined with Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating), treats a combined total of 790,000 BCY of contaminated soils in the Former Basin F Subgroup. RF heating raises the temperature of the soil to more than 250°C, mobilizing the organic contaminants. The mobilized contaminants are collected and treated in the off-gas treatment system described in Section 4.5.29. Two types of RF heating units, deep and shallow, are used for treatment of the human health organic exceedance volume of 700,000 BCY and the biota exceedance volume of 89,000 BCY. The deep unit treats a 100-ft-long, 48-ft-, 10-ft-wide block of soil, while the shallow unit treats a 100-ft-long, 36-ft-wide, 5-ft-deep block. Former Basin F has a soil moisture content of approximately 10 percent, so the treatment rate is 180 and 160 BCY/day for the deep and shallow units, respectively. The liquid sidestream from in situ heating, which contains predominantly salts, is transported to the thermal desorption facility for treatment with the scrubber effluent. Although the existing cover is not contaminated and is not targeted for treatment by this alternative, it is heated to treat the underlying contaminated soils, destroying the organic carbon in the cover soil. For this reason, a 6-inch layer of topsoil, obtained off post, is placed over the 420,000-SY treated area to provide a growth medium for vegetation. The treated areas are then revegetated with native grasses to restore the habitat.

Table 12.5-7 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. RF heating can theoretically achieve Human Health and Biota RAOs through treatment. Residual risk is considered within the acceptable range since all OCPs and volatile metals can be driven from the soils by this form of in situ thermal desorption. However, the pilot-scale test of the RF technology within the Former Basin F at RMA failed to confirm the temperature distribution and OCP removal required for confident treatment of soils to achieve PRGs. For this subgroup, Human Health PRGs are generally met and for the remaining contaminants, the residual levels of OCPs are anticipated to be within the acceptable risk range for human health (from 10^{-6} to 10^{-4} excess cancer risk). However, Biota PRGs are not met. The treated areas are revegetated to improve habitat, but some biota risk remains due to the failure to achieve PRGs. Migration of contaminants to groundwater is reduced through treatment. The implementability of in situ RF heating is questionable since there is no commercial source for the equipment and the technique is as yet unproven at full scale. RF treatment of 790,000 BCY of contaminated soils is feasible within a total of 12 years. The total estimated present worth cost of this alternative is $240,000,000. Table B4.4-19a details the costing for this alternative.

12.6 FORMER BASIN F SUBGROUP SELECTION OF PREFERRED ALTERNATIVE

The Former Basin F site consists of 790,000 BCY of exceedance soils that were not removed from Basin F during the Basin F IRA in 1989. A soil cover averaging 3 ft in thickness was placed over these remaining soils and the cover was revegetated at the conclusion of the IRA. OCPs and chloroacetic acid are the primary exceedance contaminants, although arsenic also exceeds the Biota SEC at this site. The concentrations of individual OCPs are above the Human Health SEC in less than 8 percent of the samples collected (Table 12.4-2). An additional 10 percent or less exceed the Biota SEC only. In general, the average concentration of OCPs in the human health exceedance volume substantially exceeds the Human Health SEC (Table 12.4-1). The average concentration of OCPs in the biota exceedance volume likewise exceeds the Biota SEC by a substantial amount.

Four percent or less of the samples analyzed for aldrin, dieldrin, and isodrin exceed the principal threat criteria (Table 12.4-2), which results in a principal threat exceedance volume of 220,000 BCY.

The soil cover installed during the IRA interrupts exposure pathways from the soils to humans and biota (excluding burrowing animals), so the residual risk is low. High concentrations of COCs are still present above the water table, so the soil cover does not provide long-term protection of groundwater from contaminants that may still be leaching to the groundwater plume identified as originating from this site. Contaminated groundwater is intercepted north of the former Basin F by the Basin F Groundwater IRA extraction system.

The Former Basin F Subgroup provides poor-quality habitat based on the vegetation types encountered at the site. Disturbance of this habitat during remedial actions does not represent a significant impact.

The presence of high levels of OCPs in some areas indicates that protection of site workers and the community is required for alternatives that involve excavation of these soils. The area excavated at any one time is limited and a daily cover or plastic liner is used to reduce odor emissions from excavations.

In summary, the Former Basin F Subgroup contains soils that exceed Human Health and Biota SEC as well as limited areas of principal threat exceedances with high OCP concentrations. The in-place soil cover limits exposure pathways, but contaminants may still leach to groundwater (and be intercepted by the groundwater treatment systems in place at RMA). In selecting the preferred alternative for this subgroup, the short-term risks of worker exposure and community concerns from the potential release of vapors must be balanced against the more long-term risk of leaving the contamination in place.

Alternative 1: No Additional Action achieves Human Health RAOs for exposure, but does not achieve Biota RAOs or improve the long-term protection of groundwater, so it is eliminated from further consideration as the preferred alternative. Alternative 1a: Direct Thermal Desorption of Principal Threat Volume; No Additional Action reduces human health and biota exposure by treating the principal threat areas, but does not achieve Human Health or Biota RAOs. Therefore, this alternative is also eliminated from consideration. Alternative 2a: Direct Thermal Desorption of Principal Threat Volume; Access Restrictions achieves Human Health and Biota RAOs through access controls and treatment of principal threat areas, but does not reduce the potential for continues groundwater contamination. Moreover, this alternative requires the elimination of 420,000 SY from use as habitat, so it too is eliminated from further consideration. The remaining four alternatives, which all consist of various containment and treatment processes achieve RAOs and meet the two DAA threshold criteria: protection of human health and the environment and compliance with action- and location-specific ARARs. They are distinguished by the five balancing criteria.

Alternative 19a: In Situ Thermal Treatment achieves RAOs, but does not reduce all concentrations to achieve Human Health PRGs of 10^{-6} excess cancer risk, which is the point of departure for treatment. The residual levels of OCPs following treatment by in situ RF heating are anticipated to be within the acceptable range of 10^{-4} to 10^{-6} risk for human health, but are not anticipated to achieve Biota PRGs throughout the treated area. In addition, this alternative is unproven for full-scale operation and has the highest cost ($240,000,000) of any alternative. The cost of Alternative 13a: Direct Thermal Desorption ($100,000,000) is significantly higher than Alternative 6c: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers with Modifications to Existing System ($58,000,000). Alternative 6d: Caps/Covers Modifications to Existing System achieves RAOs through containment only. Alternative 6c achieves RAOs through a combination of treatment and containment, but requires long-term monitoring and maintenance of the cap. This alternative permanently reduces TMV and achieves the EPA preference for treatment of highly contaminated materials.

The preferred alternative for the Former Basin F Subgroup is Alternative 6c: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers with Modifications to Existing System. This alternative is cost effective as it treats the principal threat volume and provides the long-term containment of untreated soils. The fewer short-term impacts from this alternative result from removing only the principal threat volume of the soils. This alternative is consistent with NCP guidance on treatment for higher levels of contamination and engineering controls (i.e., containment) for lower levels of contamination. The groundwater control system evaluated for the Basins C and F Plume is located north of the former Basin F. As such, the selection of this alternative does not impact the evaluation of groundwater alternatives.

12.7 BASIN F EXTERIOR SUBGROUP CHARACTERISTICS

The Basin F Exterior Subgroup is composed of sites NCSA-4a (Deep Disposal Well Facility) and NCSA-4b (Basin F Exterior) (Figure 12.0-1). Site NCSA-4a was the site of a facility used to dispose of Basin F wastewater by deep-well injection into bedrock at approximately 12,000 ft below ground surface. Site NCSA-4b encompasses an area of contaminated soil adjacent to the former Basin F that likely resulted from windblown contamination. The Basin F Exterior Subgroup is not considered a source of groundwater contamination.

Table 12.7-1 provides a summary of contaminants, concentrations, and corresponding exceedance values for this subgroup. Table 12.7-2 summarizes detections for samples taken in this subgroup. The soils contain OCPs exceeding both the Human Health and Biota SEC. Fewer than 2 percent of the samples for any contaminant exceed the Human Health SEC. More than 95 percent of the 80,000 BCY of human health exceedance volume is located within the 0- to 1-ft depth interval, although some contamination extends to 10 ft in site NCSA-4a. Dieldrin (420 ppm average) exceeds the principal threat criteria (10^{-3} excess cancer risk, HI of 1,000) in 34,000 BCY of soils from 0 to 1 ft below ground surface. This principal threat exceedance area is not addressed with specific treatment or containment alternatives based on concerns relative to the practicality of identifying and removing principal threat exceedances governed by an isolated exceedance in one

boring. Figure 12.7-1 shows the distribution of exceedance areas, excluding the principal threat area, for this subgroup, and Table 12.0-1 summarizes exceedance areas and volumes.

The habitat values for sites in the Basin F Exterior Subgroup range from poor to high. The habitat value is predominantly considered of poor quality, but some of the eastern portion of this subgroup is located in a prairie dog colony area, which is considered a high-quality habitat. For most of the alternatives for this subgroup, the areas disturbed during remedial actions are revegetated with native grasses in accordance with a refuge management plan. In most instances, the overall habitat value is improved, which offsets the short-term loss of habitat resulting from remedial actions. The institutional controls alternative includes provisions for modifying the habitat by seeding lower-quality grasses to reduce the desirability of the area for biota. In this instance, the habitat quality is lowered and the available habitat area for biota on RMA is reduced.

12.8 BASIN F EXTERIOR SUBGROUP EVALUATION OF ALTERNATIVES

The alternatives for the Basin F Exterior Subgroup vary in approach from no action to treatment. The alternatives retained from the DSA for this subgroup were modified to include changes in nomenclature to indicate clearly that solidification of inorganics was not required following organics treatment (Alternative 13a versus Alternative 13). An additional containment alternative was also developed to include consolidation prior to containment due to the widespread and shallow nature of the contamination. Alternative 9, which includes both soil washing and thermal desorption, was not considered for this subgroup since soils in this subgroup do not contain salts. Alternative 19 was modified for this subgroup to include two in situ heating processes in order to address various depths of contamination. The following subsections present a description of each retained alternative for this subgroup and an evaluation of the alternative against the EPA criteria for the DAA. The alternatives for this subgroup consist of an alternative to address human health exceedances (which is listed first) and an alternative for areas with biota exceedances (the "B" alternative).

12.8.1 Alternative 1/B1: No Additional Action

Alternative 1: No Additional Action (Provisions of FFA), along with Alternative B1: No Additional Action (Provisions of FFA), applies to all 2,300,000 SY of exceedance area in the Basin F Exterior Subgroup. The 530,000 BCY of human health and biota exceedance volume remain in place. No action is taken to reduce human or biota exposure to COCs. Exceedance areas are monitored over the long term (an average of 4 samples per year). Five-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Table 12.8-1 details the evaluation of this alternative against the EPA criteria for the DAA. Human Health and Biota RAOs are not achieved under this alternative as untreated soils remain in place without controls being initiated. The residual risk is relatively low due to the low levels of contamination found in the soil, with the exception of a restricted area of higher dieldrin concentrations. Natural attenuation of contamination is ongoing, but the estimated time frame to achieve PRGs is more than 30 years. The predominantly poor-quality habitat at the sites is not changed. The total estimated present worth cost of this alternative is $440,000. Table B4.5-1 details the costing for this alternative.

12.8.2 Alternative 2/B2: Access Restrictions

Alternative 2: Access Restrictions (Modifications to FFA), paired with Alternative B2: Biota Management (Exclusion, Habitat Modification), leaves 530,000 BCY of exceedance volume in place, but interrupts exposure pathways by initiating access controls. Human and biota access to the site are restricted by the installation of 22,000 ft of perimeter chain-link fence with warning signs. Over a 3-year period, 2,300,000 SY is revegetated with lower-quality grasses to reduce the value of the habitat for wildlife and promote biota exclusion from the site. The habitat modifications and fencing require long-term maintenance to ensure the effectiveness of these controls. To prevent inadvertent exposures, an ongoing public education program is implemented to illustrate the importance of respecting access restrictions to the site. Exceedance areas are monitored over the long term (an average of four samples per year). Five-year site

reviews are conducted to review effectiveness of the alternative and to assess natural attenuation/degradation and potential migration of contaminants.

Table 12.8-2 presents a detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health RAOs by interrupting exposure pathways and leaves a low residual biota risk at the sites as biota exclusion is initiated over a widespread habitat. The 2,300,000 SY of predominantly poor-quality habitat at the site is eliminated for biota. The overall time frame for achieving RAOs is 3 years. The total estimated present worth cost of this alternative is $2,800,000. Table B4.5-2a details the costing for this alternative.

12.8.3 Alternative 6/B9: Caps/Covers

Alternative 6: Caps/Covers (Clay/Soil Cap), in combination with Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) (Clay/Soil Cap), involves the installation of a 260,000-SY low-permeability soil cap to contain the human health exceedance area and the in situ treatment of 2,000,000 SY of biota exceedances. (Section 4.6.8 discusses low-permeability soil caps in detail.) Before any cover materials are installed, the subgrade is compacted and crowned with common fill and soils to achieve the design grades of 1.5 to 3 percent. The cap consists of a 2-ft layer of compacted low-permeability soil, a 1-ft biota barrier of cobbles, and a 4-ft soil/vegetation layer that includes 6 inches of topsoil. Topsoil is obtained off post and most materials for the clay/soil cap are obtained from on-post borrow areas. The cap is revegetated and burrowing animals are excluded to prevent damage to the containment system. The borrow area is recontoured and revegetated. Maintenance activities, such as grass mowing and replacement of eroded cap materials, ensures the continued integrity of the soil cover. Five-year site reviews are conducted to review the effectiveness of the alternative and to assess potential migration of contaminants.

Landfarm/agricultural practice is performed over 2,000,000 SY of biota exceedance area during a period of 2 years. The tilling and mixing of the soils in the uppermost 12 to 18 inches of the exceedance area is accomplished with traditional farm equipment. The in situ treatment reduces

the mobility of contaminants and minimizes the potential for contact with contaminated surficial soils. In addition, agricultural studies have shown that the concentrations of OCPs decrease with time when subjected to the landfarm/agricultural practice process. The treatment of this area by this process results in fewer short-term impacts to biota as the areas treated can be easily revegetated with native grasses to restore the habitat. Long-term soil monitoring and 5 year site reviews are performed for the treated area to observe attenuation/degradation of contaminants and potential migration of contaminants into subsurface soils.

Table 12.8-3 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs through containment and treatment. The cap reduces the potential for migration of contaminants to groundwater by reducing infiltration and interrupts exposure pathways for human health and biota. The capping operations take approximately 2 years to complete, and habitat is improved at the site after remediation, although burrowing animals are excluded from the area. Landfarm/agricultural practice reduces surficial contaminant levels in the biota exceedance area. The total estimated present worth cost of this alternative is $20,000,00. Table B4.5-6 details the costing for this alternative.

12.8.4 <u>Alternative 6g/B9: Caps/Covers with Consolidation</u>

Alternative 6g: Caps/Covers (Clay/Soil Cap) with Consolidation, along with Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice), involves the consolidation and containment of 80,000 BCY of human health exceedance and the in situ treatment of 2,100,000 SY of biota exceedance.

80,000 BCY of human health exceedances are excavated, transported to Basin A, consolidated as grading fill over the more highly contaminated soil present in the basin, and contained there with a clay/soil cap. (Section 4.6.8 discusses details of low-permeability soil caps.) Selection of this alternative is predicated by the selection of Alternative 6f for Basin A. As discussed in Section 10.2.4, containment of Basin A requires a large amount of grading fill, so consolidation

of contaminated soils from the Basin F Exterior Subgroup helps meet the need for grading fill in Basin A. The excavated areas are then covered with clean borrow material from an on-post borrow area, and covered with topsoil obtained off post. The area is then revegetated with native grasses. The borrow area is recontoured and revegetated. Long-term maintenance at Basin A ensures the integrity of the clay/soil cap, but no maintenance activities are required for the human health exceedance areas in the Basin F Exterior Subgroup since the exceedance soils are contained in Basin A.

Landfarm/agricultural practice is performed over 2,000,000 SY of biota exceedance area during a period of 2 years. The tilling and mixing of the soils in the uppermost 12 to 18 inches of the exceedance area is accomplished with traditional farm equipment. The in situ treatment reduces the mobility of contaminants and minimizes the potential for contact with contaminated surficial soils. In addition, agricultural studies have shown that the concentrations of OCPs decrease with time when subjected to the landfarm/agricultural practice process. The treatment of this area by this process results in fewer short-term impacts to biota as the areas treated can be easily revegetated with native grasses to restore the habitat. Long-term soil monitoring and 5-year site reviews are performed for the treated area to observe attenuation/degradation of contaminants and potential migration of contaminants into subsurface soils.

Table 12.8-4 presents the detailed evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health and Biota RAOs and PRGs through consolidation and containment of remaining human health exceedances in Basin A, and landfarm/agricultural practice to treat surficial-soil contamination. Habitat is improved at the site after remediation and is restored at the borrow area. While no monitoring is required for the sites that have been excavated, long-term monitoring is performed on the landfarmed surficial soils. The total estimated present worth cost of this alternative is $5,600,000. Table B4.5-6g details the costing for this alternative.

12.8.5 Alternative 13a/B9: Direct Thermal Desorption

Alternative 13a: Direct Thermal Desorption (Direct Heating) treats 80,000 BCY of human health exceedance soils from the Basin F Exterior Subgroup while Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) addresses 2,000,000 SY of surficial soil biota exceedances. The centralized thermal desorption facility takes approximately 1 year to build and requires another year for testing before soils can be processed. The thermal desorber has a soils processing rate of approximately 2,000 BCY/day based on the anticipated moisture content of 10 percent for soils in this subgroup. The thermal desorber operates with a soil discharge temperature of 300°C and has a soils residence time of 30 minutes. (Section 4.6.24 discusses emission controls for off gases from thermal desorption.) Approximately 1 percent of the total feed (800 BCY) is recovered as particulates from scrubber blowdown and is disposed in the on-post hazardous waste landfill. The treated soils are returned to the site excavations as backfill and are covered with 6 inches of topsoil because the thermal treatment destroys the natural organic content of the soil.

The biota exceedance area of 2,000,000 SY is treated through landfarm/agricultural practices over a period of 2 years. The tilling and mixing of the upper 12 to 18 inches of the exceedance area is accomplished with traditional farm equipment. The in situ treatment reduces the mobility of contaminants and minimizes the potential for contact with contaminated surficial soils. In addition, agricultural studies have shown that the concentrations of OCPs decrease with time when subjected to the landfarm/agricultural practice process. The treatment of this area by this process results in fewer short-term impacts to biota as the areas treated can be easily revegetated. A total of 2,300,000 SY, which includes the treated human health area as well as the landfarmed area, is revegetated with native grasses to restore the habitat. Long-term soil monitoring and 5-year site reviews are performed for the landfarmed area to observe the attenuation/degradation of contaminants and the potential migration of contaminants into subsurface soils.

Table 12.8-5 details the evaluation of this alternative against the EPA criteria for the DAA. This alternative achieves Human Health RAOs since all contaminated soils are treated to remove or

destroy the exceedance COCs. Biota RAOs are also achieved since the contaminant levels in the surficial soils and the volume of contaminated soils above the Biota SEC are reduced through treatment. The residual risk achieves PRGs. The habitat is improved at the site after revegetation. Including the construction and testing of the thermal desorption facility, a total of 3 years is required to achieve RAOs. The total estimated present worth cost of this alternative is $11,000,000. Table B4.5-13a details the costing estimate for this alternative.

12.8.6 Alternative 19b/B9: In Situ Thermal Treatment

Alternative 19b: In Situ Thermal Treatment (RF/Microwave Heating, Surface Soil Heating) treats 80,000 BCY of human health exceedance soils while Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) addresses 2,000,000 SY of surficial soils with biota exceedance. The two in situ heating process options, RF heating and surface soil heating, raise the temperature of the soil to more than 250°C, mobilizing the organic contaminants. (Section 4.6.30 discusses details of these technologies.) The mobilized contaminants are collected and treated in the off-gas treatment system described in Sections 4.4.9 and 4.5.29. One RF unit is used to treat contaminants to a depth of 10 ft in 2,000-BCY blocks of soil with a moisture content of approximately 10 percent. The RF unit can treat a 100-ft-long, 48-ft-wide, 10-ft-deep block of soil at a rate of approximately 180 BCY/day. Only one surface soil unit is required for the treatment of surficial soils. The surface soil unit treats a 50- by 50-ft block of soil at a rate of approximately 17,000 SY/year. The liquid sidestream from in situ heating, which contains predominantly salts, is transported to the thermal desorption facility for treatment with the scrubber effluent. Thermal treatment destroys the organic content in the soil, so a 6-inch layer of topsoil, obtained off post, is placed over the treated human health organic exceedance area of 260,000 SY to provide a medium for vegetation.

The biota exceedance area of 2,000,000 SY is treated through landfarm/agricultural practice over a period of 2 years. The tilling and mixing of the upper 12 to 18 inches of the exceedance area is accomplished with traditional farm equipment. The in situ treatment reduces the mobility of contaminants and minimizes the potential for contact with contaminated surficial soils. In

addition, agricultural studies have shown that the concentrations of OCPs decrease with time when subject to the landfarm/agricultural practice. The treatment of this area by this process results in fewer short-term impacts to biota as the areas treated can be easily revegetated. A total of 2,300,000 SY, which includes the treated human health area as well as the landfarmed area, is revegetated with native grasses to restore the habitat. Long-term soil monitoring and 5-year site reviews are performed for the landfarmed area to observe attenuation/degradation of contaminants and the potential migration of contaminants into subsurface soils.

Table 12.8-6 details the evaluation of this alternative against the EPA criteria for the DAA. RF heating can theoretically achieve Human Health RAOs with low residual risk since all OCPs and volatile metals can be driven from the soil by this form of in situ thermal desorption. However, the pilot-scale test of the RF technology at RMA failed to confirm the temperature distribution and OCP removal required for confident treatment of soils to achieve PRGs. For most contaminants, Human Health PRGs are achieved; the residual levels of dieldrin are anticipated to be within the acceptable risk range for human health (10^{-6} to 10^{-4} excess cancer risk). However, Biota PRGs are not achieved. The implementability of in situ RF heating is questionable since there is no commercial source for the equipment and the technique is as yet unproven at full scale. OCP contamination in biota exceedance areas is reduced by landfarm/agricultural practices. The treatment of the contaminated soil in this subgroup is feasible within 5 years, and habitat in the exceedance areas is improved by revegetation. The estimated total present worth cost of this alternative is $21,000,000. Table B4.5-19b details the costing of this alternative.

12.9 BASIN F EXTERIOR SUBGROUP SELECTION OF PREFERRED ALTERNATIVE

The Basin F Exterior Subgroup contains 530,000 BCY of soils with OCP exceedances. Human health and biota exceedances are primarily within the 0- to 1-ft depth interval, although some contamination extends to 10 ft in site NCSA-4a. The concentration of individual OCPs are below CRLs or the Biota SEC in more than 80 percent of the samples collected. Only 1.2 percent or less of the individual OCP samples exceed the Human Health SEC (Table 12.7-2). The two sites

in this subgroup present a relatively low risk to human health as the average concentrations of OCPs within the human health exceedance volume are less than the Human Health SEC (except for dieldrin) (Table 12.7-1). Two samples for dieldrin in an isolated boring exceed the principal threat criteria. Average OCP concentrations in the biota exceedance volume are higher than the Biota SEC.

In general, the habitat present in sites in this subgroup is poor, although the eastern portion is located in a prairie dog area that is considered a high-quality habitat. Alternatives that disrupt habitat include revegetation to restore and improve habitat quality following remediation.

Excavation of human health exceedances requires protection for site workers, but special measures for odor control and community protection are not anticipated based on the generally low levels of contamination present in this subgroup.

In summary, it is predominantly surficial soils contamination that exceed Human Health and Biota SEC in this subgroup. Based on the characteristics of the subgroup, habitat impacts and community protection are not significant factors for consideration in selecting the preferred alternative.

Alternative 1: No Additional Action does not achieve Human Health or Biota RAOs as uncontained and untreated contaminated soils remain in the surficial soils with no controls being initiated. This alternative is consequently eliminated from further consideration as the preferred alternative. The remaining four alternatives, which involve varying degrees of treatment and containment, achieve RAOs; and are protective of human health and the environment and comply with action- and location-specific ARARs, thus satisfying both of the threshold criteria. The alternatives differ however, in how they meet the five balancing criteria.

Alternative 19b: In Situ Thermal Treatment achieves RAOs, generally reduces concentrations to achieve Human Health PRGs at 10^{-6} excess cancer risk, which is the point of departure for

treatment, and reduces any residual levels of OCPs to within the acceptable range of 10^{-4} to 10^{-6} risk for human health. Treatment by in situ RF heating is not anticipated to achieve Biota PRGs throughout the treated area. In addition, this alternative is unproven for full-scale operation and has the highest cost ($27,000,000) of any alternative. Alternative 2: Access Restrictions has the lowest cost of the four alternatives ($2,800,000), but is the least protective as 530,000 BCY of untreated soils are left in place. This alternative reduces human exposure, but leaves moderate residual risk for biota. This alternative also eliminates 2,300,000 SY of habitat for biota. Alternative 13a: Direct Thermal Desorption achieves RAOs through thermal desorption or containment for human health exceedance areas and by in situ landfarm/agricultural practice for biota exceedance areas, but the cost of Alternative 13a: Direct Thermal Desorption ($11,000,000) is higher than either of the containment alternatives that achieve RAOs. Alternative 6g: Caps/Covers with Consolidation exhibits a slightly lower cost ($5,600,000) than Alternative 6: Caps/Covers ($20,000,000) and results in the improvement in habitat quality over additional 260,000 SY.

The preferred alternative for the Basin F Exterior Subgroup is Alternative 6g: Caps/Covers with Consolidation. This alternative is the most cost effective because contaminated soil is consolidated in Basin A. The contaminated soil from Basin F Exterior contributes to the large volume of soils needed to regrade Basin A prior to capping. Consolidation of the soil in Basin A reduces overall monitoring costs at RMA as only Basin A needs to be monitored. The selection of this alternative is consistent with NCP guidance on engineering controls for lower levels of contamination. Alternative 6g: Caps/Covers with Consolidation also improves habitat in the long term over a 2,300,000-SY area.

Table 12.0–1 Characteristics of the Secondary Basins Medium Group

Characteristic	Secondary Basins Subgroup	Former Basin F Subgroup	Basin F Exterior Subgroup
Contaminants of Concern			
Human Health	OCPs,	OCPs, DCPD, CLC2A	OCPs
Biota	OCPs, As, Hg	OCPs, As	OCPs
Exceedance Areas (SY)			
Total	430,000	420,000	2,300,000
Human Health	10,000	370,000	260,000
Biota	420,000	57,000	2,000,000
Potential Agent	not applicable	not applicable	not applicable
Potential UXO	not applicable	not applicable	not applicable
Exceedance Volume (BCY)			
Total	300,000	790,000	530,000
Human Health	6,800	700,000	80,000
Organic	6,800	700,000	80,000
Inorganic	0	0	0
Principal Threat	0	220,000	34,000
Biota	290,000	89,000	450,000
Potential Agent	not applicable	not applicable	not applicable
Potential UXO	not applicable	not applicable	not applicable
Depth of Contamination (ft)			
Human Health	0–10	0–10, mostly 0–5	0–10
Biota	0–10, mostly 0–1	0–10, mostly 0–3	0–10, mostly 0–1

Table 12.1-1 Summary of Concentrations for the Secondary Basins Subgroup

Contaminants of Concern	Range of Concentrations[2] (ppm)	Average Concentration[2] (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC (ppm)
Human Health Exceedance Volume					
Aldrin	BCRL–95	35.4	56	560	0.68
Dieldrin	BCRL–83	44.3	40	400	0.83
Chlordane	BCRL–3.8	0.15	3.1	260	not applicable
Endrin[1]	BCRL–0.24	0.032	15	15,000	0.029
Arsenic[1]	BCRL–66	17.6	530	5,300	16.5
Mercury[1]	0.005–1.6	0.12	470	470,000	0.99
Biota Exceedance Volume					
Aldrin	BCRL–24	0.67	56	560	0.68
Dieldrin	BCRL–32	1.3	40	400	0.83
Endrin	BCRL–2.0	0.084	15	15,000	0.029
p,p,DDE	BCRL–0.79	0.015	130	1,300	0.2
Arsenic	BCRL–140	12	530	5,300	16.5
Mercury	BCRL–1.2	0.49	470	470,000	0.99

1 Present above Biota SEC only, but was detected in the human health exceedance volume.
2 Based on modeled concentrations within exceedance volume.

Table 12.1-2 Frequency of Detections for Secondary Basins Subgroup

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	575	317	55.1%	222	38.6%	32	5.6%	4	0.7%	0	0.0%
Benzene	112	112	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	107	107	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	560	550	98.2%	9	1.6%	--	--	1	0.2%	0	0.0%
Chloroacetic Acid	49	49	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlorobenzene	106	106	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroform	107	107	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	575	556	96.7%	16	2.8%	3	0.5%	0	0.0%	0	0.0%
p,p,DDT	575	552	96.0%	22	3.8%	1	0.2%	0	0.0%	0	0.0%
Dibromochloropropane	185	185	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	107	107	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	185	185	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	575	193	33.6%	240	41.7%	131	22.8%	11	1.9%	0	0.0%
Endrin	575	305	53.0%	85	14.8%	185	32.2%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	542	541	99.8%	1	0.2%	--	--	0	0.0%	0	0.0%
Isodrin	575	509	88.5%	64	11.1%	--	--	2	0.3%	0	0.0%
Methylene Chloride	56	49	87.5%	7	12.5%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	107	107	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Toluene	112	112	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	107	107	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	343	197	57.4%	120	35.0%	26	7.6%	0	0.0%	0	0.0%
Cadmium	312	272	87.2%	40	12.8%	--	--	0	0.0%	0	0.0%
Chromium	312	49	15.7%	263	84.3%	--	--	0	0.0%	0	0.0%
Lead	312	215	68.9%	97	31.1%	--	--	0	0.0%	0	0.0%
Mercury	328	274	83.5%	51	15.5%	3	0.9%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.

Table 12.2-1 Evaluation of Alternative 1: No Additional Action (Provisions of FFA); Alternative B1: No Additional Action (Provisions of FFA) for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Does not achieve Human Health or Biota RAOs as untreated soils if controls are not implemented. Long-term reduction in toxicity of contaminants through natural attenuation; groundwater impacts not reduced.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs as long-term monitoring and site reviews achieved.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Secondary Basins Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Low concentrations of OCPs above Human Health SEC and mercury, arsenic, and OCPs above Biota SEC remain in soil and may impact human health and biota.
b) Adequacy and reliability of controls	b) No controls implemented. Site reviews and groundwater monitoring required.
c) Habitat impacts	c) Habitat quality not improved. Existing poor-quality habitat not impacted by remedial alterr.ative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction of contaminant volume or mobility except by natural attenuation; 300,000 BCY of untreated soils remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or vapor emissions.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Existing poor-quality habitat not impacted by remedial alternative; migration of contaminants to groundwater not reduced.
d) Time until RAOs are achieved	d) >30 years. Natural attenuation only process for contaminant reduction.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Monitoring services readily available.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $3,100,000
d) Total	d) $3,100,000

Table 12.2-2 Evaluation of Alternative 2: Access Restrictions (Modifications to FFA); Alternative B2: Biota Management (Exclusion, Habitat Modification) for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs as human and biota exposure pathways interrupted through access restrictions and biota controls; groundwater impacts not reduced.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs as access adequately controlled and site reviews conducted; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Secondary Basins Subgroup not located in wetlands or 100-year flood plains.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. OCPs above Human Health SEC and mercury, arsenic, and OCPs above Biota SEC remain in soil; fencing, land-use restrictions, and cultivation of lower-quality habitat reduce human and biota exposure.
b) Adequacy and reliability of controls	b) Adequate controls. Installation of fencing, land-use restrictions, and biota controls reduce exposure; long-term maintenance, site reviews, groundwater monitoring, and monitoring of wildlife exclusion required.
c) Habitat impacts	c) Habitat quality eliminated. Biota controls of fencing and cultivation of lower-quality habitat eliminate habitat for biota.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction of contaminant volume or mobility except by natural attenuation for 300,000 BCY of untreated soils; human and biota exposure pathways interrupted over 430,000 SY by land-use restrictions, fencing, and biota controls.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Exposure controls reversible if fencing or biota controls fail.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative. Contaminants remain in place with highest levels of contamination at depth.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during fence installation and cultivation of lower-quality habitat.
b) Protection of community during remedial action	b) Protective of community. Dust and vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater not reduced.
d) Time until RAOs are achieved	d) 3 years. Installation of perimeter fencing within several months but cultivation of lower-quality habitat requires 3 years; natural attenuation of untreated soils ongoing.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably maintained thereafter; additional remedial actions easily undertaken for soils left in place.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment readily available for fence installation and habitat modifications.

Table 12.2-2 Evaluation of Alternative 2: Access Restrictions (Modifications to FFA); Alternative B2: Biota Management (Exclusion, Habitat Modification) for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $650,000
b) Operating	b) $160,000
c) Long-term	c) $3,300,000
d) Total	d) $4,100,000

Table 12.2-3 Evaluation of Alternative 6: Caps/Covers (Clay/Soil Cap); Alternative B5: Caps/Covers (Clay/Soil Cap) for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; contaminated soils contained by clay/soil cap, preventing human and biota exposure; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-5)	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Secondary Basins Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 300,000 BCY of untreated soils contained through installation of 430,000-SY clay/soil cap.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for untreated soils; erosion control and vegetative cover maintenance required; high confidence in engineering controls of clay/soil cap.
c) Habitat improved	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat; restrictions to burrowing animals help preserve integrity of cap and prevent exposure.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Exposure pathways interrupted and mobility of contaminants reduced through installation of 430,000 SY of clay/soil cap.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if cap degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during installation of clay/soil cap.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact on biota due to existing poor-quality habitat; burrowing animals excluded from area.
d) Time until RAOs are achieved	d) 2 years. Installation of 430,000 SY-clay/soil cap feasible within 2 years; natural attenuation of untreated soils ongoing.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably maintained thereafter; additional remedial actions easily undertaken for soils left in place, although cap adds to overall site volume.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of cap/cover design and construction regulations.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment readily available for clay/soil cap construction; clay/soil caps well demonstrated at full scale.

7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $23,000,000
c) Long-term	c) $11,000,000
d) Total	d) $34,000,000

Table 12.2-4 Evaluation of Alternative 6g: Caps/Covers (Clay/Soil Cap) with Consolidation; Alternative B5a: Caps/Covers (Clay/Soil Cap) with Consolidation for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; contaminated soils above Human Health and Biota SECs excavated and consolidated in Basin A for containment with clay/soil cap, preventing exposure; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-5)	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Secondary Basins Subgroup and Basin A not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 300,000 BCY of soil consolidated and contained in Basin A with clay/soil cap.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for Basin A; high confidence in engineering controls of clay/soil cap in Basin A.
c) Habitat improved	c) Habitat improved at site. Revegetation of disturbed areas improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. Exposure pathways interrupted and mobility of contaminants reduced through consolidation of 300,000 BCY of contaminated soils in Basin A and installation of clay/soil cap.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if Basin A cap degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation and transportation.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 1 year. Consolidation of 300,000 BCY in Basin A feasible within 1 year.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative implemented within required time frame and reliably maintained thereafter; additional remedial actions require removal of cap/cover.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of cap/cover design and construction regulations.
c) Availability of services and materials	c) Readily implemented. Equipment, specialists, and materials readily available for consolidation and clay/soil cap construction; clay/soil caps well demonstrated at full scale.

Table 12.2-4 Evaluation of Alternative 6g: Caps/Covers (Clay/Soil Cap) with Consolidation; Alternative B5a: Caps/Covers (Clay/Soil Cap) with Consolidation for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $11,900,000
c) Long-term	c) $0
d) Total	d) $11,900,000

Table 12.2-5 Evaluation of Alternative 13a: Direct Thermal Desorption (Direct Heating); Alternative B6: Direct Thermal Desorption (Direct Heating) for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to OCP detection levels and inorganics reduced below Biota SEC; blowdown solids placed in on-post landfill; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, and A-10)	a) Complies with action-specific ARARs including state regulations on air emission sources and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Secondary Basins Subgroup, thermal desorption facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 300,000 BCY of soil thermally desorbed and returned to site as backfill; approximately 1% of soils feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Backfill monitoring not required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 300,000 BCY thermally desorbed to degrade OCPs and remove mercury.
b) Degree and quantity of TMV reduction	b) Organics reduced below detection levels (>99.99% destruction removal efficiency); TMV of organics eliminated; mercury removed below Biota SEC; arsenic reduced below Biota SEC following solids blending as a pre-treatment and limited volatilization during thermal desorption (20 to 30%); scrubber blowdown solids from off-gas treatment equipment with mercury, arsenic, and salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible.
d) Type and quantity of treatment residuals	d) 3,000 BCY of blowdown solids with mercury, arsenic, and salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation; vapor emissions associated with thermal desorber controlled by air emissions control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 3 years. Excavation and treatment of 300,000 BCY feasible within 1 year after 2 years for construction of thermal desorption facility and landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cell monitored.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment unit operation and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers; equipment, specialists, and materials readily available for construction of landfill; thermal desorbers and landfills well demonstrated at full scale.

Table 12.2-5 Evaluation of Alternative 13a: Direct Thermal Desorption (Direct Heating); Alternative B6: Direct Thermal Desorption (Direct Heating) for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $7,800,000
b) Operating	b) $33,000,000
c) Long-term	c) $11,000
d) Total	d) $41,000,000

Table 12.2-6 Evaluation Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating); Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating) for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-13)	a) Complies with action-specific ARARs including state regulations on air emissions sources; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Secondary Basins Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk within acceptable range. 300,000 BCY thermally treated in place, but PRGs not achieved; reduction in OCP levels within acceptable levels for human health and biota.
b) Adequacy and reliability of controls	b) Controls not required. Monitoring of treated soil not required.
c) Habitat improved	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, but some biota risk remains as Biota PRGs not achieved.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 300,000 BCY thermally treated to degrade OCPs and remove mercury.
b) Degree and quantity of TMV reduction	b) Reductions from RF heating (97-99.9% destruction removal efficiency) unable to achieve PRGs. TMV of organics reduced during RF treatment; mercury condensed in blowdown liquid.
c) Irreversibility of TMV reduction	c) TMV reduction by in situ RF heating irreversible.
d) Type and quantity of treatment residuals	d) Liquid blowdown sidestream with elevated mercury, arsenic, and salts treated at thermal desorption facility with scrubber effluent.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during in situ thermal treatment.
b) Protection of community during remedial action	b) Protective of community. No fugitive dust emissions; vapor emissions associated with RF heating unit controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 6 years. RF heating of 300,000 BCY feasible within 16 years.
6. Implementability	
a) Technical feasibility	a) Potentially technically feasible. Pilot-scale testing of RF heating on soil with similar contaminants but unproven at full scale; additional remedial actions easily undertaken for treated soils that do not achieve PRGs.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment system siting, design, and operating regulations.
c) Availability of services and materials	c) Limited availability. Equipment custom designed for each application and not available; specialists only available through process licensor IITRI; no full-scale demonstration of RF equipment.

Table 12.2-6 Evaluation Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating); Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating) for the Secondary Basins Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $26,000,000
b) Operating	b) $100,000,000
c) Long-term	c) $0
d) Total	d) $130,000,000

Table 12.4–1 Summary of Concentrations for the Former Basin F Subgroup

Contaminants of Concern	Range of Concentrations[2] (ppm)	Average Concentration[2] (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC (ppm)
Human Health Exceedance Volume					
Aldrin	BCRL–2,900	340	56	560	0.68
Dieldrin	BCRL–1,400	110	40	400	0.83
Endrin	BCRL–610	40	15	15,000	0.029
Isodrin	BCRL–7,500	360	3.4	3,400	not applicable
CLC2A	BCRL–6,900	880	74	74,000	not applicable
DCPD	BCRL–15,000	700	1,200	1,000,000	not applicable
p,p,DDT[1]	BCRL–15	0.05	26	1,300	1.4
Arsenic[1]	BCRL–45	5.2	530	5,300	16.5
Biota Exceedance Volume					
Aldrin	BCRL–18	2.3	56	560	0.68
Dieldrin	BCRL–16	2.0	40	400	0.83
Endrin	BCRL–5.5	0.62	15	15,000	0.029
Arsenic	0.51–41	8.5	530	5,300	16.5

1 Present above Biota SEC only, but was detected in the human health exceedance volume.
2 Based on modeled concentrations within exceedance volume.

Table 12.4-2 Frequency of Detections for Former Basin F Subgroup

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed(3)	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	181	148	81.8%	9	5.0%	11	6.1%	7	3.9%	6	3.3%
Benzene	159	152	95.6%	7	4.4%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	141	141	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	180	179	99.4%	1	0.6%	--	--	0	0.0%	0	0.0%
Chloroacetic Acid	87	61	70.1%	5	5.7%	--	--	21	24.1%	0	0.0%
Chlorobenzene	135	133	98.5%	2	1.5%	--	--	0	0.0%	0	0.0%
Chloroform	141	132	93.6%	9	6.4%	--	--	0	0.0%	0	0.0%
p,p,DDE	182	181	99.5%	1	0.5%	0	0.0%	0	0.0%	0	0.0%
p,p,DDT	181	180	99.4%	0	0.0%	0	0.0%	1	0.6%	0	0.0%
Dibromochloropropane	186	179	96.2%	7	3.8%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	141	140	99.3%	1	0.7%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	181	161	89.0%	14	7.7%	--	--	6	3.3%	0	0.0%
Dieldrin	181	133	73.5%	17	9.4%	18	9.9%	6	3.3%	7	3.9%
Endrin	181	151	83.4%	5	2.8%	15	8.3%	10	5.5%	0	0.0%
Hexachlorocyclopentadiene	180	179	99.4%	1	0.6%	--	--	0	0.0%	0	0.0%
Isodrin	181	157	86.7%	9	5.0%	--	--	14	7.7%	1	0.6%
Methylene Chloride	127	123	96.9%	4	3.1%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	141	130	92.2%	11	7.8%	--	--	0	0.0%	0	0.0%
Toluene	158	140	88.6%	18	11.4%	--	--	0	0.0%	0	0.0%
Trichloroethylene	141	140	99.3%	1	0.7%	--	--	0	0.0%	0	0.0%
Arsenic	161	75	46.6%	77	47.8%	9	5.6%	0	0.0%	0	0.0%
Cadmium	185	169	91.4%	16	8.6%	--	--	0	0.0%	0	0.0%
Chromium	185	20	10.8%	165	89.2%	--	--	0	0.0%	0	0.0%
Lead	175	118	67.4%	57	32.6%	--	--	0	0.0%	0	0.0%
Mercury	161	101	62.7%	60	37.3%	0	0.0%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.
(3) Presents all data including samples for soil removed during Basin F IRA. All data were utilized in contaminant modeling of remaining soil.

Table 12.5-1 Evaluation of Alternative 1: No Additional Action (Provisions of FFA); Alternative B1: No Additional Action (Provisions of FFA) for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Achieves Human Health RAOs with existing cap but not Biota RAOs as untreated, capped soils not adequately controlled to prevent biota exposure. Long-term reduction in toxicity of contaminants due to natural attenuation; groundwater impacts not reduced beyond protection provided by existing cap.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs as long-term monitoring and site reviews achieved.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Low levels of OCPs, DCPD, and CLC2A above Human Health SEC and OCPs and arsenic above Biota SEC remain in capped soils and may impact human health and biota.
b) Adequacy and reliability of controls	b) No additional controls implemented beyond existing cap. Site reviews and groundwater monitoring required.
c) Habitat impacts	c) Habitat quality not improved. Existing poor-quality habitat not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No additional reduction in contaminant volume or mobility beyond existing cap except by natural attenuation; 790,000 BCY of untreated soils remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Exposure controls reversible if existing cap degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or vapor emissions.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Existing poor-quality habitat not impacted by remedial alternative; migration of contaminants to groundwater reduced by existing cap.
d) Time until RAOs are achieved	d) >30 years. Natural attenuation only process for contaminant reduction.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Monitoring services readily available.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $7,200,000
d) Total	d) $7,200,000

Table 12.5-2 Evaluation of Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA); Alternative B1: No Additional Action (Provisions of FFA) for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Achieves Human Health RAOs with existing cap but does not achieve Biota RAOs as untreated, capped soils remain, although principal threat volume treated. Long-term reduction in toxicity of contaminants through natural attenuation for balance of areas; principal threat volume treated to organic detection levels and arsenic reduced below Biota SEC; blowdown solids placed in on-post landfill; groundwater impacts not reduced beyond protection provided by existing cap except for principal threat volume.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, and A-10)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Former Basin F Subgroup, thermal desorption facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Capped soils contain OCPs and CLC2A above Human Health SEC and OCPs above Biota SEC remain in soil; 220,000 BCY thermally desorbed and returned to site as backfill; approximately 1% of soils feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) No additional controls implemented beyond existing cap for balance of site, but adequate controls for particulates; site reviews and groundwater monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality not improved for balance of site; habitat restored for principal threat area through revegetation; existing poor-quality habitat for balance of site not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 220,000 BCY of principal threat volume thermally desorbed to degrade OCPs, DCPD, and CLC2A; no reduction in contaminant volume or mobility except by natural attenuation for balance of site; 570,000 BCY of untreated soils remain but capped.
b) Degree and quantity of TMV reduction	b) Organics reduced below detectable levels (>99.99% destruction and removal efficiency); TMV of organics eliminated; arsenic reduced below Biota SEC following solids blending as a pre-treatment and limited volatilization during thermal desorption (20 to 30%); scrubber blowdown solids from off-gas treatment equipment with arsenic and salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible; exposure controls reversible if existing cap leaks or degrades.
d) Type and quantity of treatment residuals	d) 2,200 BCY of blowdown solids with arsenic and salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation, transportation, and treatment of principal threat volume.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; odor and vapor emissions controlled by limited excavation and daily soil covers or plastic liners; vapor emissions associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced but not prevented.
d) Time until RAOs are achieved	d) >30 years. Excavation and treatment of 220,000 BCY feasible within 1 year after 2 years for construction of thermal desorption facility; natural attenuation of untreated soils ongoing.

Table 12.5-2 Evaluation of Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA); Alternative B1: No Additional Action (Provisions of FFA) for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; landfill cell monitored; additional remedial actions easily undertaken for soils left in place.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment system and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers; equipment, specialists, and materials readily available for landfill construction; thermal desorbers and landfills well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $5,700,000
b) Operating	b) $23,000,000
c) Long-term	c) $6,500,000
d) Total	d) $35,000,000

Table 12.5-3 Evaluation of Alternative 2a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modifications to FFA); Alternative B2: Biota Management (Exclusion, Habitat Modification) for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs as human and biota exposure pathways interrupted through existing cap controls; principal threat volume treated to below organic detection levels; blowdown solids placed in on-post landfill; groundwater impacts not reduced beyond protection provided by existing cap.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, and A-10)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation; access adequately controlled and site reviews conducted; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Former Basin F Subgroup, thermal desorption facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Capped soil with CLC2A and OCPs above Human Health SEC at depth; biota controls of fencing and cultivation of lower-quality habitat reduce biota exposure to OCPs; 220,000 BCY thermally desorbed and returned to site as backfill; approximately 1% of soils feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Exposure pathways interrupted by existing cap, fencing, land-use restrictions, and biota controls; long-term maintenance, site reviews, groundwater monitoring, and wildlife exclusion monitoring required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality eliminated. Principal threat area restored through revegetation; biota controls consist of fencing and cultivation of lower-quality habitat.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 220,000 BCY of principal threat volume thermally desorbed to degrade OCPs, DCPD, and CLC2A; no reduction of contaminant volume or mobility except by natural attenuation for 570,000 BCY of soils; human and biota exposure pathways interrupted by land-use restrictions, fencing, and biota controls of more than 420,000 SY.
b) Degree and quantity of TMV reduction	b) Organics reduced below detectable levels (>99.99% destruction removal efficiency); TMV of organics eliminated; arsenic reduced below Biota SEC following solids blending as a pre-treatment and limited volatilization during thermal desorption (20 to 30%); scrubber blowdown solids from off-gas treatment equipment with arsenic and salts contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible; exposure controls reversible if existing cap, fencing, and biota controls fail.
d) Type and quantity of treatment residuals	d) 2,200 BCY of blowdown solids with salts landfilled; contaminants for balance of area remain in place with highest levels of contamination at depth.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during installation of controls and excavation, transportation, and treatment of principal threat volume.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; odor and vapor emissions controlled by limited excavation and daily soil covers or plastic liners; vapor emissions associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced but not prevented.
d) Time until RAOs are achieved	d) 3 years. Excavation and treatment of 220,000 BCY feasible within 1 year after 2 years for construction of thermal desorption facility and landfill; installation of perimeter fencing and cultivation of lower-quality habitat feasible within 3 years; natural attenuation of untreated soils ongoing.

Table 12.5-3 Evaluation of Alternative 2a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modifications to FFA); Alternative B2: Biota Management (Exclusion, Habitat Modification) for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; landfill cell monitored; additional remedial actions easily undertaken for soils left in place although existing soil cover would require removal.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment system and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Controls readily implemented. Several vendor sources available for design and construction of thermal desorbers; materials, specialists, and equipment readily available for installation of fencing, habitat modification, and landfill construction; thermal desorbers and landfill well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $6,000,000
b) Operating	b) $23,000,000
c) Long-term	c) $6,700,000
d) Total	d) $36,000,000

Table 12.5-4 Evaluation of Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Modifications to Existing System; Alternative B5b: Caps/Covers with Modifications to Existing System for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment of principal threat volume and containment of balance of areas; principal threat volume treated to organic detection levels and arsenic reduced below Biota SEC; contaminated soils for balance of areas contained by modifications to existing clay/soil cap, preventing human and biota exposure; blowdown solids placed in on-post landfill; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material; state regulations on air emissions sources and landfill siting, design, and operation achieved; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Former Basin F Subgroup, thermal desorption facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 220,000 BCY thermally desorbed and returned to site as backfill; human and biota exposure pathways interrupted through modification to 420,000-SY clay/soil cap; approximately 1% of soils feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for untreated soils; erosion control and vegetative cover maintenance required; no difficulties associated with landfill maintenance; high confidence in engineering controls of clay/soil cap and landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat; restrictions to burrowing animals help preserve integrity of cap and prevent exposure.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 220,000 BCY thermally desorbed to degrade OCPs, CLC2A, and DCPD; human and biota exposure pathways interrupted and mobility of contaminants reduced through modification of 420,000-SY clay/soil cap.
b) Degree and quantity of TMV reduction	b) Organics reduced below detection levels (>99.99% destruction removal efficiency); TMV of organics eliminated; arsenic reduced below Biota SEC following solids blending as a pre-treatment and limited volatilization during thermal desorption (20 to 30%); scrubber blowdown solids from off-gas treatment equipment with arsenic and salts placed in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV by thermal desorption irreversible; mobility reduction reversible if cap/cover degrades or leaks.
d) Type and quantity of treatment residuals	d) 2,200 BCY of blowdown solids with arsenic and salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during cap/cover modification and excavation, transportation, and treatment of principal threat volume.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; odor and vapor emissions controlled by limited excavation and daily soil covers or plastic liners; vapor emissions associated with thermal desorber controlled by air emissions control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact on biota due to existing poor-quality habitat; burrowing animals excluded from area.
d) Time until RAOs are achieved	d) 3 years. Excavation and treatment of 220,000 BCY feasible within 1 year after 2 years for construction of thermal desorption facility; modification of 420,000-SY clay/soil cap feasible within 1 year; natural attenuation of untreated soils ongoing.

Table 12.5-4 Evaluation of Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap) with Modifications to Existing System; Alternative B5b: Caps/Covers with Modifications to Existing System for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; landfill cell monitored; additional remedial actions easily undertaken for soils left in place, although cap adds to overall site volume.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment system and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers; equipment, specialists, and materials readily available for clay/soil cap and landfill construction; thermal desorbers and landfills well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $5,700.000
b) Operating	b) $42,000,000
c) Long-term	c) $10,000,000
d) Total	d) $58,000,000

Table 12.5-5 Evaluation of Alternative 6d: Caps/Covers (Clay/Soil Cap) with Modifications to Existing System; Alternative B5b: Caps/Covers with Modifications to Existing System for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment of contaminated soils by modifications to existing clay/soil cap, preventing human and biota exposure; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Former Basin F Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 790,000 BCY of untreated soils contained through modification to existing 420,000-SY clay/soil cap.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for untreated soils; erosion control and vegetative cover maintenance required.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat; restrictions to burrowing animals help preserve integrity of cap and prevent exposure.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated; human and biota exposure pathways interrupted and mobility of contaminants reduced through modification of 420,000-SY clay/soil cap.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if cap degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during cap/cover modification.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact on biota due to existing poor-quality habitat; burrowing animals excluded from area.
d) Time until RAOs are achieved	d) 1 year. modification of 420,000-SY clay/soil cap feasible within 1 year; natural attenuation of untreated soils ongoing.

Table 12.5-5 Evaluation of Alternative 6d: Caps/Covers (Clay/Soil Cap) with Modifications to Existing System; Alternative B5b: Caps/Covers with Modifications to Existing System for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; additional remedial actions easily undertaken for soils left in place, although cap adds to overall site volume.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of clay/soil cap design and construction regulations.
c) Availability of services and materials	c) Readily available. Equipment, specialists, and materials readily available for cap modification; clay/soil caps well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $20,000,000
c) Long-term	c) $11,000,000
d) Total	d) $31,000,000

Table 12.5-6 Evaluation of Alternative 13a: Direct Thermal Desorption (Direct Heating); Alternative B6: Direct Thermal Desorption (Direct Heating) for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to organic detection levels and arsenic reduced below Biota SEC; blowdown solids placed in on-post landfill; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with action-specific ARARs as Former Basin F Subgroup, thermal desorption facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provision of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 790,000 BCY thermally desorbed and returned to site as backfill; approximately 1% of soils feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Backfill monitoring not required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed area improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 790,000 BCY thermally desorbed to degrade OCPs, CLC2A, and DCPD.
b) Degree and quantity of TMV reduction	b) Organics reduced below detectable levels (>99.99% destruction removal efficiency); TMV of organics eliminated; arsenic reduced below Biota SEC following solids blending as a pre-treatment and limited volatilization during thermal desorption (20 to 30%); scrubber blowdown solids from off-gas treatment equipment with arsenic and salts placed in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption irreversible.
d) Type and quantity of treatment residuals	d) 7,900 BCY of blowdown solids with arsenic and salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; odor and odor emissions controlled by limited excavation and daily soil covers or plastic liners; vapor emissions associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 4 years. Excavation and treatment of 790,000 BCY feasible within 2 year after 2 years for construction of thermal desorption facility and landfill.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cell monitored.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment system and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers; equipment, specialists, and materials readily available for construction of landfill; thermal desorbers and landfills well demonstrated at full scale.

Table 12.5-6 Evaluation of Alternative 13a: Direct Thermal Desorption (Direct Heating); Alternative B6: Direct Thermal Desorption (Direct Heating) for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $21,000,000
b) Operating	b) $82,000,000
c) Long-term	c) $26,000
d) Total	d) $100,000,000

Table 12.5-7 Evaluation of Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating); Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating) for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment, generally achieves Human Health PRGs, but Biota PRGs not achieved; groundwater impacts reduced.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A	a) Complies with action-specific ARARs including state regulations on air emission sources; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Former Basin F Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk within acceptable range. 790,000 BCY thermally treated in place, Human Health PRGs generally achieved; reduction in OCP levels within acceptable levels for human health (10^{-4} to 10^{-6} excess cancer risk); arsenic above Biota PRGs remains in soils.
b) Adequacy and reliability of controls	b) Controls not required. Monitoring of treated soil not required.
c) Habitat improved	c) Habitat quality improved. Revegetation of disturbed area improves existing poor-quality habitat but some biota risk remains as Biota PRGs not achieved.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 790,000 BCY thermally treated to degrade organics.
b) Degree and quantity of TMV reduction	b) Reductions from RF heating (97-99.9% destruction removal efficiency) unable to achieve Biota PRGs. TMV of organics reduced during RF treatment but concentrations after treatment not able to achieve biota PRGs; OCP levels in treated soils within acceptable range for human health (10^{-4} to 10^{-6} excess cancer risk).
c) Irreversibility of TMV reduction	c) TMV reduction by RF heating irreversible.
d) Type and quantity of treatment residuals	d) Liquid blowdown sidestream with elevated salts treated at thermal desorption facility along with scrubber effluent.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during in situ thermal treatment.
b) Protection of community during remedial action	b) Protective of community. No fugitive dust emissions; vapor emissions associated with RF heating unit controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impact. Minimal impact to biota due to existing poor-quality habitat; migration of contaminants to groundwater reduced.
d) Time until RAOs are achieved	d) 12 years. RF heating of 790,000 BCY feasible within 12 years.
6. Implementability	
a) Technical feasibility	a) Potentially technically feasible. Pilot-scale testing of RF heating on soil with similar contaminants but unproven at full-scale; additional remedial actions easily undertaken for treated soils that do not achieve PRGs.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment system siting, design, and operating regulations.
c) Availability of services and materials	c) Limited availability. Equipment custom designed for each application and not available; specialists only available through process licensor IITRI; no full-scale demonstration of RF equipment.

Table 12.5-7 Evaluation of Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating); Alternative B11a: In Situ Thermal Treatment (RF/Microwave Heating) for the Former Basin F Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $26,000,000
b) Operating	b) $210,000,000
c) Long-term	c) $0
d) Total	d) $240,000,000

Table 12.7–1 Summary of Concentrations for the Basin F Exterior Subgroup

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Principal Threat Criteria (ppm)	Biota SEC (ppm)
Human Health Exceedance Volume					
Aldrin	0.47–210	41	56	560	0.68
Dieldrin	2.2–920	420	40	400	0.83
Endrin	0.14–37	7.2	15	15,000	0.029
Isodrin	0.033–6.7	1.5	3.4	3,400	not applicable
Biota Exceedance Volume					
Aldrin	BCRL–15	2.2	56	560	0.68
Dieldrin	BCRL–29	1.2	40	400	0.83
Endrin	BCRL–4.2	0.21	15	15,000	0.029

[1] Based on modeled concentrations within exceedance volume.

Table 12.7-2 Frequency of Detections for Basin F Exterior Subgroup

	Total Samples	BCRL		CRL-SEC(1)		Biota SEC-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	248	185	74.6%	46	18.5%	16	6.5%	1	0.4%	0	0.0%
Benzene	124	122	98.4%	2	1.6%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	108	108	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	247	241	97.6%	6	2.4%	--	--	0	0.0%	0	0.0%
Chloroacetic Acid	11	11	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlorobenzene	108	108	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroform	108	108	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	248	242	97.6%	6	2.4%	0	0.0%	0	0.0%	0	0.0%
p,p,DDT	248	231	93.1%	17	6.9%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	246	245	99.6%	1	0.4%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	108	108	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	1	1	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	246	244	99.2%	2	0.8%	--	--	0	0.0%	0	0.0%
Dieldrin	248	173	69.8%	47	19.0%	26	10.5%	0	0.0%	2	0.8%
Endrin	248	185	74.6%	19	7.7%	43	17.3%	1	0.4%	0	0.0%
Hexachlorocyclopentadiene	245	241	98.4%	4	1.6%	--	--	0	0.0%	0	0.0%
Isodrin	248	210	84.7%	35	14.1%	--	--	3	1.2%	0	0.0%
Methylene Chloride	108	92	85.2%	16	14.8%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	65	64	98.5%	1	1.5%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	108	106	98.1%	2	1.9%	--	--	0	0.0%	0	0.0%
Toluene	124	124	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	108	108	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	184	112	60.9%	72	39.1%	0	0.0%	0	0.0%	0	0.0%
Cadmium	225	219	97.3%	6	2.7%	--	--	0	0.0%	0	0.0%
Chromium	225	11	4.9%	213	94.7%	--	--	1	0.4%	0	0.0%
Lead	225	134	59.6%	91	40.4%	--	--	0	0.0%	0	0.0%
Mercury	226	197	87.2%	29	12.8%	0	0.0%	0	0.0%	0	0.0%

(1) SEC limit for this interval is Biota SEC for compounds with Biota criteria and HH SEC for remaining compounds.
(2) Table 1.4-1 presents Biota SEC, HH SEC, and Principal Threat Criteria.

Table 12.8-1 Evaluation of Alternative 1: No Additional Action (Provisions of FFA); Alternative B1: No Additional Action (Provisions of FFA) for the Basin F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Does not achieve Human Health or Biota RAOs as untreated soils remain if controls are not implemented. Long-term reduction in toxicity of contaminants due to natural attenuation; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs	a) Complies with action-specific ARARs including long-term monitoring and site reviews.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Exterior Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Low levels of OCPs (except for restricted area of higher dieldrin concentrations) above Human Health and Biota SEC remain in soil and may impact human health and biota.
b) Adequacy and reliability of controls	b) No controls implemented. Long-term monitoring and site reviews required.
c) Habitat impacts	c) Habitat quality not improved. Existing poor-quality habitat not impacted by remedial alternative.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction in contaminant volume or mobility except by natural attenuation; 530,000 BCY of untreated soils remain.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) (See a.)
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. No workers involved.
b) Protection of community during remedial action	b) Protective of community. No fugitive dusts or vapor emissions.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Existing poor-quality habitat not impacted by remedial alternative.
d) Time until RAOs are achieved	d) >30 years. Natural attenuation only process for contaminant reduction.
6. Implementability	
a) Technical feasibility	a) Technically feasible. No implementation action required.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Monitoring services readily available.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $0
c) Long-term	c) $440,000
d) Total	d) $440,000

Table 12.8-2 Evaluation of Alternative 2: Access Restrictions (Modifications to FFA); Alternative B2: Biota Management (Exclusion, Habitat Modification) for the Basin F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through interruption of human and biota exposure pathways through access restrictions and biota controls for balance of area; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, and A-10)	a) Complies with action-specific ARARs as access adequately controlled and site reviews conducted; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Exterior Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. Low levels of OCPs (except for restricted area at higher dieldrin concentratins) remain in soil; biota controls of fencing and cultivation of lower-quality habitat reduce human and biota exposure to contaminants.
b) Adequacy and reliability of controls	b) Adequate controls. Exposure pathways interrupted by fencing, land-use restrictions, and biota controls; long-term maintenance, site reviews, and monitoring of wildlife exclusion required.
c) Habitat impacts	c) Habitat quality eliminated. Biota controls consist of fencing and cultivation of lower-quality habitat.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) No materials treated. No reduction of contaminant volume or mobility except by natural attenuation for 530,000 BCY of soils; human and biota exposure pathways interrupted over 2,300,000 SY by land-use restrictions, fencing, and biota barriers.
b) Degree and quantity of TMV reduction	b) (See a).
c) Irreversibility of TMV reduction	c) Exposure controls reversible if fencing and biota controls fail.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with this alternative contaminants remain in place.

Table 12.8-2 Evaluation of Alternative 2: Access Restrictions (Modifications to FFA); Alternative B2: Biota Management (Exclusion, Habitat Modification) for the Basin F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during fence installation and cultivation of lower quality habitat.
b) Protection of community during remedial action	b) Protective of community. Dust and vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to poor-existing poor-quality habitat.
d) Time until RAOs are achieved	d) 3 years. Installation of perimeter fencing and cultivation of lower-quality habitat feasible within 3 years; natural attenuation of untreated soils ongoing.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; additional remedial actions easily undertaken for soils left in place.
b) Administrative feasibility	b) Administratively feasible. No permitting required.
c) Availability of services and materials	c) Readily implemented. Equipment, specialists, and materials readily available for fence installation, and habitat modification.
7. Present worth costs	
a) Capital	a) $720,000
b) Operating	b) $800,000
c) Long-term	c) $1,300,000
d) Total	d) $2,800,000

Table 12.8-3 Evaluation of Alternative 6: Caps/Covers (Clay/Soil Cap); Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Basins F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; contaminated soils, contained by clay/soil cap, preventing human and biota exposure; biota exceedances treated by landfarming; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-5)	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Exterior Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Low residual risk. 80,000 BCY of untreated soils contained through installation of 260,000-SY clay/soil cap; 2,000,000 SY landfarmed to reduce TMV.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required for untreated soils; erosion control and vegetative cover maintenance required; high confidence in engineering controls of clay/soil cap.
c) Habitat improved	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat; restrictions to burrowing animals help preserve integrity of cap and prevent exposure.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) Exposure pathways interrupted and mobility of contaminants reduced through installation of 260,000-SY of clay/soil cap; 2,000,000 SY landfarmed, reducing TMV.
b) Degree and quantity of TMV reduction	b) (See a.)
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if cap degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during installation of clay/soil cap and agricultural practices.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact on biota due to existing poor-quality habitat; burrowing animals excluded from area.
d) Time until RAOs are achieved	d) 2 years. Installation of 260,000 SY clay/soil cap feasible within 1 year; landfarming of 2,000,000 SY feasible within 2 years.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably maintained thereafter; additional remedial actions easily undertaken for soils left in place, although cap adds to overall site volume.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of cap/cover design and construction regulations.
c) Availability of services and materials	c) Readily implemented. Materials, specialists, and equipment readily available for clay/soil cap construction; clay/soil caps well demonstrated at full scale.

Table 12.8-3 Evaluation of Alternative 6: Caps/Covers (Clay/Soil Cap); Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Basins F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $13,000,000
c) Long-term	c) $6,900,000
d) Total	d) $20,000,000

Table 12.8-4 Evaluation of Alternative 6g: Caps/Covers (Clay/Soil Cap) with Consolidation; Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Basin F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through containment; contaminated soils above Human Health SEC excavated and consolidated in Basin A for containment by clay/soil cap; biota exceedances treated by landfarming; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (See Technology Description Document, Appendix A, Tables A-1, A-5, A-8, and A-10)	a) Complies with action-specific ARARs regarding construction of covers and monitoring of contained material; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin A and Basin F Exterior Subgroup, not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs at site. 80,000 BCY of soil consolidated and contained in Basin A with clay/soil cap; 2,000,000 SY landfarmed to reduce TMV.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required; high confidence in engineering controls associated with clay/soil cap in Basin A.
c) Habitat impacts	c) Habitat quality improved at site. Revegetation of disturbed area improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) Exposure pathways interrupted and mobility of contaminants reduced through consolidation of 80,000 BCY of contaminated soils in Basin A and installation of clay/soil cap in Basin A; 2,000,000 SY landfarmed reducing TMV.
b) Degree and quantity of TMV reduction	b) (See a).
c) Irreversibility of TMV reduction	c) Mobility reduction reversible if Basin A cap/cover degrades or leaks.
d) Type and quantity of treatment residuals	d) No treatment residuals associated with alternative.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation, transportation, and agricultural practices.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat.
d) Time until RAOs are achieved	d) 2 years. Consolidation of 80,000 BCY in Basin A feasible within 1 year; landfarming of 2,000,000 SY feasible within 2 years.

Table 12.8-4 Evaluation of Alternative 6g: Caps/Covers (Clay/Soil Cap) with Consolidation; Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Basin F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated and maintained thereafter; additional remedial actions would require removal of cap/cover in Basin A.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of cap/cover design and construction regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for agricultural practices; equipment, specialists, and materials readily available for clay/soil cap; clay/soil caps well demonstrated at full scale.
7. Present worth costs	
a) Capital	a) $0
b) Operating	b) $5,300,000
c) Long-term	c) $360,000
d) Total	d) $5,600,000

Table 12.8-5 Evaluation of Alternative 13a: Direct Thermal Desorption (Direct Heating); Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Basin F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment; contaminated soils treated to OCP detection levels; blowdown solids placed in on-post landfill; no unacceptable short-term risks or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1, A-8, and A-10)	a) Complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Exterior Subgroup, thermal desorption facility, and landfill not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidances	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk achieves PRGs. 80,000 BCY thermally desorbed and returned to site as backfill; 2,000,000 SY landfarmed to reduce TMV; approximately 1% of soils feed recovered from off-gas treatment equipment placed in on-post landfill.
b) Adequacy and reliability of controls	b) Adequate controls. Long-term monitoring and site reviews required; no difficulties associated with landfill maintenance; high confidence in engineering controls associated with landfill.
c) Habitat improved	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, offsetting loss during excavation.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 80,000 BCY thermally desorbed to degrade OCPs; 2,000,000 SY landfarmed, reducing TMV.
b) Degree and quantity of TMV reduction	b) OCPs reduced below detection levels (>99.99% destruction removal efficiency). TMV of OCPs eliminated; scrubber blowdown solids with salts from off-gas treatment equipment contained in on-post landfill.
c) Irreversibility of TMV reduction	c) TMV reduction by thermal desorption and agricultural practice irreversible.
d) Type and quantity of treatment residuals	d) 800 BCY of blowdown solids with salts landfilled.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during excavation, transportation, and treatment.
b) Protection of community during remedial action	b) Protective of community. Fugitive dusts controlled by water spraying; vapor emissions not anticipated from excavation; vapor emissions associated with thermal desorber controlled by air emission control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat.
d) Time until RAOs are achieved	d) 3 years. Excavation and treatment of 80,000 BCY feasible within 1 year after 2 years for construction of thermal desorption facility and landfill; agricultural practice for 2,000,000 SY feasible within 3 years.
6. Implementability	
a) Technical feasibility	a) Technically feasible. Alternative constructed within required time frame and reliably operated thereafter; landfill cell monitored.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment system and landfill siting, design, and operating regulations.
c) Availability of services and materials	c) Readily available. Several vendor sources available for design and construction of thermal desorbers and agricultural practices; equipment, specialists, and materials readily available for construction of landfill; thermal desorbers and landfills well demonstrated at full scale.

Table 12.8-5 Evaluation of Alternative 13a: Direct Thermal Desorption (Direct Heating); Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Basin F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
7. Present worth costs	
a) Capital	a) $2,100,000
b) Operating	b) $11,000,000
c) Long-term	c) $370,000
d) Total	d) $14,000,000

Table 12.8-6 Evaluation of Alternative 19b: In Situ Thermal Treatment (RF/Microwave Heating, Surface Soil Heating); Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Basin F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
1. Overall protection of human health and environment	Protective of human health and environment. Achieves RAOs through treatment, generally achieves Human Health PRGs, but Biota PRGs not achieved; no unacceptable short-term or cross-media impacts.
2. Compliance with ARARs	
a) Action-specific ARARs (see Technology Description Document, Appendix A, Tables A-1 and A-13)	a) Complies with action-specific ARARs including state regulations on air emissions sources; endangered species not impacted.
b) Location-specific ARARs (see Soils DSA, Volume II, Appendix A, Table A-2)	b) Complies with location-specific ARARs as Basin F Exterior Subgroup not located in wetlands or 100-year floodplain.
c) Criteria, advisories, and guidance	c) Complies with provisions of FFA.
3. Long-term effectiveness and permanence	
a) Magnitude of residual risks	a) Residual risk within acceptable range. 80,000 BCY thermally treated in place, but Biota PRGs not achieved; reduction of OCP levels within acceptable levels for human health (10^{-4} to 10^{-6} excess cancer risk); 2,000,000 SY landfarmed, to reduce TMV in surficial soils.
b) Adequacy and reliability of controls	b) Controls not required. Long-term monitoring and site reviews required.
c) Habitat impacts	c) Habitat quality improved. Revegetation of disturbed areas improves existing poor-quality habitat, but some biota risk remains as Biota PRGs not achieved.
4. Reduction in TMV	
a) Treatment process used and materials treated	a) 2,000 BCY thermally treated by RF heating to degrade OCPs; 75,000 SY thermally treated by surface soil heating to degrade OCPs; 2,000,000 SY landfarmed, reducing TMV.
b) Degree and quantity of TMV reduction	b) Reductions from RF heating (97-99.9% destruction removal efficiency) unable to achieve Biota PRGs. TMV of OCPs reduced during RF treatment generally able to achieve Human Health PRGs; residual OCP levels in treated soils within acceptable range for human health (10^{-4} to 10^{-6} excess cancer risk).
c) Irreversibility of TMV reduction	c) TMV reduction by in situ RF heating and landfarming irreversible.
d) Type and quantity of treatment residuals	d) Liquid blowdown sidestream with salts treated at thermal desorption facility along with scrubber effluent.
5. Short-term effectiveness	
a) Protection of workers during remedial action	a) Protective of workers. Personnel protective equipment adequately protects workers during in situ treatment.
b) Protection of community during remedial action	b) Protective of community. No fugitive dust emissions; vapor emissions associated with RF heating controlled by air emissions control equipment.
c) Environmental impacts of remedial actions	c) Minimal environmental impacts. Minimal impact to biota due to existing poor-quality habitat.
d) Time until RAOs are achieved	d) 5 years. RF treatment of 80,000 BCY feasible within 1 year; landfarming of 2,000,000 SY feasible within 2 years; surface soil heating feasible within 5 years.

Table 12.8-6 Evaluation of Alternative 19b: In Situ Thermal Treatment (RF/Microwave Heating, Surface Soil Heating); Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) for the Basin F Exterior Subgroup

CRITERIA	ALTERNATIVE EVALUATION
6. Implementability	
a) Technical feasibility	a) Potentially feasible. Pilot-scale testing of RF heating on soil with similar contaminants but unproven at full scale; additional remedial actions easily undertaken for treated soils that do not achieve PRGs.
b) Administrative feasibility	b) Administratively feasible. Achieves substantive requirements of treatment system siting, design, and operating regulations.
c) Availability of services and materials	c) Limited availability. Equipment custom designed for each application and not available; specialists only available through process licensor IITRI; no full-scale demonstration of RF equipment; several vendor sources available for agricultural practices.
7. Present worth costs	
a) Capital	a) $14,000,000
b) Operating	b) $6,500,000
c) Long-term	c) $390,000
d) Total	d) $21,000,000